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EDITORIAL

THE AGRICULTURAL CONFERENCE

THE Fourth Agricultural Conference commenced at Peradeniya on the 20th of October. On the first day His Excellency the Governor (Sir Herbert James Stanley, G.C.M.G.) presided and was supported by the Hon'ble Mr. B. H. Bourdillon, C.M.G., Colonial Sercetary, as Vice-Chairman. At the morning session on this day, after a few introductory remarks and a welcome to His Excellency by the Director of Agriculture on behalf of the Board and Department of Agriculture, His Excellency addressed the Conference and expressed his pleasure at the good attendance and at the presentation of the reports of the enquiry into the conditions of paddy cultivation in the Island, an enquiry which he himself had suggested two years previously.

His Excellency thanked the members of the Local Sub-Committees established by the Food Products Committee who had given much valuable service in reporting upon the conditions of paddy growing in their districts. He reviewed the work of the Estate Products and Food Products Committees and stressed the importance of retaining within the Island as much as possible of the huge sum annually sent out for the purchase of foreign rice.

His Excellency expressed his great sympathy and concern for the depressed rubber and coconut industries.

In the afternoon of the first day the Board of Agriculture held its meeting at which the chief subject for discussion was the recommendation by the Food Products Committee asking that Government might be pleased to appoint a Commission to investigate the whole subject of paddy production in the Island. The Board decided to take this course. His Excellency again presided on the second day and was supported at the morning session by Mr. A. G. Baynham, Chairman of the Planters' Association of Ceylon and in the afternoon by Mr. G. Robert de Zoysa, Vice-Chairman of the Low-Country Products' Association.

At the third day's session the Chairman in the morning was Mr. H. W. Codrington, Government Agent, Central Province, with Sir H. Marcus Fernando as Vice-Chairman. In the afternoon Sir Solomon Dias Bandaranaike, K.C.M.G., was Chairman, with the Hon'ble Mr. E. R. Tambimuttu, M.L.C., supporting him as Vice-Chairman.

PROGRAMME OF AGRICULTURAL CONFERENCE AT PERADENIYA 1930

MONDAY, OCTOBER 20, MORNING SESSION

ADDRESS BY HIS EXCELLENCY THE GOVERNOR

1. A Short Note on a Study of the Economics of Rice Growing in Ceylon, by the Hon'ble Mr. W. A. de Silva, M.L.C.
2. Some Points regarding the Increase of the Production of Paddy in Ceylon, by Mr. C. V. Brayne, B.A., C.C.S.
3. Paddy Cultivation, by Mr. K. Kanagasabai.
4. Some Points of Interest that have emerged from the Investigations of the Sub-Committees connected with Paddy Cultivation, by the Hon'ble Sir H. Marcus Fernando, Kt., M.D., B.Sc.

MONDAY, OCTOBER 20, AFTERNOON

MEETING OF THE BOARD OF AGRICULTURE

(a) Minutes of last Meeting.

(b) Confirmation of Nominations to Committees.

(c) Resolutions on Paddy Cultivation.

TUESDAY, OCTOBER 21, MORNING SESSION

Paper 1.—Curing of Sheet Rubber, by Mr. T. E. H. O'Brien, M.Sc., A.I.C., Chemist, Rubber Research Scheme (Ceylon).

Paper 2.—Control of Oidium, by Mr. R. K. S. Murray, A.R.C.S., Mycologist, Rubber Research Scheme (Ceylon).

Paper 3.—Robusta Coffees and their Commercial Possibilities, by Mr. T. H. Holland, M.C., V.D., Dip. Agric. (Wye), Manager, Experiment Station, Peradeniya.

TUESDAY, OCTOBER 21, AFTERNOON SESSION

Paper 4.—Some Problems of Coconut Research, by the Hon'ble Sir H. Marcus Fernando, Kt., M.D., B.Sc.

Paper 5.—Replanting and Rejuvenation of Old Rubber, by R. A. Taylor, B.Sc., Physiological Botanist, Rubber Research Scheme (Ceylon).

PRIZE-DISTRIBUTION AT FARM SCHOOL

WEDNESDAY, OCTOBER 22, MORNING SESSION

Paper 6.—Notes on Paddy Fly, by Dr. J. C. Hutson, B.A., Ph. D., Entomologist.

Paper 7.—Some Diseases of Plantains in Ceylon, by Mr. Malcolm Park, A.R.C.S., Acting Mycologist.

Paper 8.—The Tenancy System in Batticaloa, by Mr. C. Ragunathan, Dip. Agric. (Poona), Assistant Registrar of Co-operative Societies.

Paper 9.—Live-stock in Ceylon, by Mr. M. Crawford, M.R.C.V.S., Assistant Government Veterinary Surgeon.

Paper 10.—Pasture Improvement, by Mr. E. J. Livera, B.Sc., Dip. Agric. (Wye). Divisional Agricultural Officer, North-Western Division.

WEDNESDAY, OCTOBER 22, AFTERNOON SESSION

Paper 11.—Cotton Cultivation in the Hambantota District, by Mr. W. R. C. Paul, M.A., M.Sc., D.I.C., F.L.S., Dip. Agric. (Cantab). Divisional Agricultural Officer, Southern Division.

Paper 12.—Agricultural Instruction in Rural Schools, by Mr. J. C. Drieberg, Dip. Agric. (Poona).

Paper 13.—Tobacco, by Mr. H. L. de Mel, C.B.E.

THE FOURTH AGRICULTURAL CONFERENCE AT PERADENIYA

OCTOBER 20-22, 1930

OCTOBER 20, 1930—MORNING SESSION

WELCOME TO HIS EXCELLENCY BY THE DIRECTOR OF AGRICULTURE

DR. W. Youngman, the Director of Agriculture, said that he rose to offer a welcome to His Excellency the Governor on behalf of the Board of Agriculture and the Department of Agriculture for consenting to preside over the Fourth Agricultural Conference. He also thanked the Colonial Secretary and other gentlemen who consented to act as Vice-Chairmen of the Conference. He offered a welcome to the members of the Board itself and also to officers of the Department of Agriculture. He also offered a welcome to visitors from various parts of the Island as well as to those from overseas. There were present a representative of the Department of Agriculture, Gambia, a gentleman from Lord Melchett's Experiment Station in England and also a gentleman once prominent in agricultural operations in Burma. One thing which inspired him with no little confidence, he said, was the large numbers of visitors who came to Peradeniya. When he asked himself the question whether the Department was working on the right lines and whether the Department was doing the right work, or doing any valuable work at all, an answer to these questions was, he thought, to be found in the numbers of distinguished visitors who came from overseas to see the work of the Department. Some gave him criticism which he welcomed. Some commented upon the valuable work being done and he thought that the fact that these visitors did come at all showed that something of value and interest was being done.

Some of this work was long range research work as well as work immediately necessary for the present times. In the difficulties that the Island was at present experiencing the Department was practising every form of economy that was wise and necessary, and that made matters a little difficult for the Department. He hoped that the policy of the public would be to offer constructive, not destructive, criticism and help them in their work.

The business they were going to transact that day and the two following days had already been presented to the members of the Board and a full programme for three days had been prepared.

OPENING ADDRESS BY HIS EXCELLENCY THE GOVERNOR

His Excellency thanked Dr. Youngman for the welcome and expressed pleasure at being in the chair. He explained why the Conference had not been held for two years, namely the interregnum between the departure of Mr. Stockdale and the arrival of Dr. Youngman. Since the last Conference the Board of Agriculture, which worked through the Food and Estate Products Committees, had not been idle. Today they were mainly concerned with the work of the former. There was a discussion at the last Conference about the difficulties impeding the growing of paddy to the extent grown in old days and at his suggestion the Conference decided to inquire into the position of the industry. His idea was that the Conference should appoint a Committee but it decided that the best course was to ask the Food Products Committee to undertake the work. That had been done and the results of the inquiry were before them in two documents published by the Department. His Excellency thanked the members of the Committees which had been established in various parts of the country, particularly the unofficial members, for undertaking a work which he was confident was well done and would have fruitful results.

A Sub-Committee of the Food Products Committee in its report on the subject had made definite recommendations to the Board of Agriculture which would reach a decision on them in the afternoon. The recommendations boiled down to this—that in the light of the information collected the time had come to appoint a Commission to formulate definite and practical proposals under various heads. He did not know whether the Board would accept the recommendations. He dared say that some of them including himself had hoped that the immediate results of the inquiry would have been more definite action than a reference to a Commission, which inevitably involved a certain amount of delay. It was clear, however, in perusing the reports of the Committees that the information which had been collected and the recommendations made required a certain amount of co-ordination and sifting, which could only be undertaken profitably by a further body. It was his hope that if a Commission were appointed, it would be able to deal with the matter expeditously and put forward proposals, which were not only ideally desirable but practically possible. His Excellency went on to comment on the recommendations *seriatim*. Though he was

hopeful as to the results of the appointment of a Commission, he did not anticipate that it would be possible to do anything very revolutionary at present, because the whole country in common with practically the whole world was suffering from an acute economic depression and the funds, which would be required to carry out the desirable proposals would not be available, and not likely to be, in the near future.

"Of course" His Excellency continued "the economic depression brings home to us the importance of doing something, if something can be done to stimulate the production of paddy. It is a sad thing that £8,000,000 a year should go out of the country for the purchase of foodstuffs, of which a certain portion, if not the whole, ought to be capable of production in the Island. If we can do something to see some portion at any rate of that amount of rice produced in the Island and some portion of money now spent in the importation of rice retained in the Island a very useful service to the country will have been rendered. There is no money available to carry out great public works in the Island. We should not lose heart and put off the whole question of paddy growing improvement to better days. Something can be done and whatever we can do will be work which is desirable and indeed necessary."

Regarding the organization and co-ordination of the services concerned with paddy cultivation, there would be no opposition as to the general principle, but there would be undoubted difficulties in carrying it out. Under the New Constitution opportunities under co-ordination in grouping the services would go some way in meeting the wishes expressed. The question of tenancy, His Excellency said, was very difficult. We were up against old established customs often founded in historical and social conditions and they had to exercise caution in interfering with them without the fullest consideration. Sometimes one did more harm than good.

Referring to anti-malaria and public health matters, His Excellency said, again it was necessary here to cut one's coat according to one's cloth. Malaria will not be stamped out by more extensive cultivation unless some additional steps were taken in order to accelerate the process of getting no disease.

Regarding anchylostomiasis the natural leaders of the people could do a great deal if they preached sanitary improvement.

With regard to means of communication again it was largely a matter of finance and at the moment he could not hold out hopes that Government would have funds to extend roads. Drainage and flood protection to some extent was a matter in which the cultivator might do a little more, as clearing elas. Flood protection schemes were expensive and if the money was

available he should be glad to see the process of flood protection accelerated and extended.

His Excellency then dwelt on other activities of the Food Products Committee, as fruit growing, in which connection he congratulated Mr. H. L. de Mel on his work, and tobacco cultivation, which was a helpful adjunct to other agricultural activities. He mentioned the possibilities of co-operation in relation to the marketing of produce as a possible question for the Commission.

Dealing with the activities of the Estate Products Committee he congratulated the three major industries on their possession of research schemes and welcomed Dr. Diamond, Director of the Coconut Research Scheme.

The tea industry was not contributing papers to the Conference this year as it was shortly having its own Conference.

An important function of the Estate Products Committee was that which related to pests and diseases which was now a question largely of entomological research. It had been said that modern life was developing into a struggle between mankind and the insect kingdom. There was a great deal of truth in it and we were becoming here in Ceylon more and more aware of the danger of the termites which had driven him out of his house and home in Colombo. He hoped the Ordinance regulating Plant Pests and Diseases would soon be amended so as to include this pest.

His Excellency concluded by expressing the great concern and sympathy he felt for the rubber and coconut industries at the present time. He suggested that the Conference generally should express its sympathy by a motion upon the subject.

His Excellency then called upon the Hon'ble Mr. W. A. de Silva to read his paper on "A Study of the Economics of Rice Growing in Ceylon."

RICE GROWING IN CEYLON

W. A. DE SILVA, M.L.C.

IN considering the question of rice growing we should at the outset guard ourselves against impressions we derive from our contact with highly organised industries. In Ceylon, rice is grown primarily to supply the immediate food needs of the cultivator. It is a primitive industry dependent largely on the labour of the cultivator. The industry is therefore one of low efficiency. Any attempt to raise the industry to higher efficiency must fail if we neglect to realise the principle that progress in agriculture has to be a progress of growth.

There is no justification for the belief expressed in many quarters that the inefficient state of the industry is due to the apathy and laziness of the cultivator. That belief is based on ignorance of existing conditions, and has been responsible for the failure of many attempts made for promoting rice growing in Ceylon. The "apathy and laziness" theory hitherto has resulted in introducing two undesirable elements in dealing with rice growing: attempts at artificial stimulation and at restriction of freedom of the cultivators.

Rice cultivation cannot be taught. It has to be practised, and this practice requires a fairly long apprenticeship. A process or method which succeeds under particular conditions does not succeed under other conditions. As an illustration one may cite that deep ploughing which succeeds in good deep soils gives bad results in light, superficial soils; transplanting that succeeds in good loams and clays gives bad results in other soils; thin sowing that succeeds in rich soils becomes a failure in poor soils; fertilisers that give good results in one place give indifferent results in another; varieties of paddy that thrive well in certain localities give poor results in other localities.

The cultivation of rice is not a whole-time occupation. The season for cultivation is restricted; the amount of labour required, even during this limited season, varies very much from day to day. The cultivator must also be prepared for bad seasons and failure of crops. He has to utilize his spare time in growing other crops and in domestic, and industrial occupation if he is to produce sufficient food for the maintenance of his family and to furnish himself with the necessities of life. A cultivator cannot live on rice alone even when he has a large supply of it. Other food is required to supplement it. Grains

and pulses, vegetables and fruits, have to be grown. Some of these products are less exacting than rice in the attention required for their success. If rice growing is to prosper the cultivator has to insure himself against the failure of his rice crop and also to find work during the period when his attention is not required for his rice crop. This indicates that he should have plenty of land for dry cultivation. The cultivation of other food products besides rice should receive every encouragement.

The principal crops that are grown on dry lands are kurakkan, meneri, mun, and tala, besides vegetables and fruit. Kurakkan yields an average of 15 bushels per acre. Meneri 8 bushels. Tala 6 bushels, and mun 4 bushels. The growth of these crops requires very much less labour than the cultivation of rice. These crops do not depend on irrigation; they do not require the use of cattle or buffaloes which is a very essential factor in rice growing.

A successful rural settlement as it existed over two thousand years ago is described by Rhys Davids in his book "Buddhist India." I quote it as it indicates the economic conditions under which a rural community could thrive:

"The houses were all together in a group separated only by narrow lanes. Immediately adjoining was the sacred grove of trees of the primeval forest left standing when the forest clearing had been made. Beyond this was the wide expanse of cultivated field usually rice field and each village had grazing ground for the cattle and a considerable stretch of jungle where the villagers had common rights of waste and wood. The cattle belonged severally to the householders of the village, but no one had separate pasture. After the crop was cut the cattle roamed over the fields. When the crops were growing they were sent all together under the charge of a herdsman, hired by the village collectively, to the village grazing grounds beyond the field."

The conditions described above have continued to exist in Ceylon as instanced by many villages to-day and others that existed up to very recent times as described by the late Mr. R. W. Ievers in his "Manual of the North-Central Province."

There are three main conditions under which rich land is held in Ceylon.

The first is where the fields are situated in thickly populated areas and where the owners of such land cultivate the fields, but do not depend on them for their livelihood. The second is the tenant cultivator who cultivates a field and pays a share to the landlord. The third is the cultivator in the tank areas who depends for his livelihood on the cultivation of paddy land by irrigation, supplemented by the cultivation of other products on dry land.

For improving the conditions under which cultivation takes place the main consideration should be the provision of facilities for a freer and liberal access to both irrigable and unirrigable land. Restrictions and control in regard to cultivation with innumerable rules and regulations instead of promoting cultivation, retard its progress. The greater the number of prohibitions and restrictions are in any public undertaking whether it is Agriculture, Sanitation, Education, or Local Government the greater the chances of failure. Regulations are a necessary evil and the success of any undertaking is in inverse proportion to the number of regulations and restrictions imposed on it.

The present Vel Vidane system and the Huvandiram tax should be completely done away with. The cultivators should elect their own Vel Vidane as their representative or spokesman. They should remunerate him or accept his voluntary services as they wish. No outside influence should be brought to compel them to be under a Vel Vidane or to pay a share of their crop to such a Vel Vidane.

There should be a definite understanding regarding irrigation facilities. The cultivators should know well ahead of the season whether they have a prospect of getting irrigation water during a particular cultivation period. If as is often the case at present they are kept in suspense till within a few weeks of the time of sowing, no good work can be expected on the land. A man cannot spend his labour unless he knows that he has a fair chance of utilizing such labour in a useful purpose.

Rice cultivation cannot be carried on without a sufficient number of cattle or buffaloes for use in its operations. The extent of land cultivated and the thoroughness of cultivation depend entirely on the number of buffaloes available. Two measures are urgently needed in regard to cattle and buffaloes if we are to look for progress in rice cultivation; the provision of communal grazing land whenever possible, and, the re-enactment of the regulations prohibiting the sale of buffaloes for slaughter. If the present rate of slaughtering buffaloes continue, rice cultivation will be confronted with a crisis from which it may not be able to recover.

The next important measure that requires attention is the improvement of facilities for transport and sale of produce. The establishment of depôts for the purchase of paddy, gingelly, kurakkan, etc., at fixed prices similar to what has been done on a limited scale in regard to tobacco in Jaffna and cotton in Hambantota, would go a great way to encourage the cultivator who in remote villages finds it impossible to sell his produce at a fair rate.

Special facilities should be afforded by the Railway to convey local produce, both by providing suitable wagons, and, by charging such rates as could stand competition. This aspect does not seem to receive the attention of our Railway. It does not provide sufficient facilities for the conveyance of perishable agricultural produce, nor does it seem to be prepared to attract new produce for transport by means of propaganda.

One of the anomalies of the working of the Ceylon Railway is its encouragement of foreign agricultural produce to the detriment of local agriculture. Rice and other agricultural produce from India is carried by the Ceylon Government Railway at 4 cents per ton per mile whereas they charge 10 cents or 150 per cent. more for Ceylon produce. The Railway also seems to discourage the cultivator and encourage the large dealer by offering special rates for produce in large quantities, for long distances.

These then are some of the economics in rice growing that require immediate and earnest attention. Research and improved methods no doubt can contribute their share, but before the industry can take advantage of improved methods these preliminary conditions of rice cultivation should receive attention.

DISCUSSION

His Excellency thanked Mr. De Silva for his interesting and instructive paper and added that they were very much indebted to him for it. Mr. De Silva's enthusiasm for the care of the villager was well known as he had not confined himself merely to words. Anybody who had visited his properties at Anuradhapura would see that he carried out his experiments on lines designed to be of real assistance to small cultivators. His Excellency then invited comments.

Mr. W. L. Kindersley said that although he was not a cultivator himself, he would make bold to put forward a definite proposal which would conform to the requirement laid down by His Excellency not to impose undue burdens on the taxpayer, and also conform to the requirement laid down by Dr. Youngman that criticisms should be constructive, and not destructive. The present policy of paddy cultivation was ridiculous. From inquiries he made, he was able to gather that the return on a bushel of sown paddy was ludicrously inadequate. In Italy and Spain, the return on a bushel of seed ranged from 60 to 80 fold. In Ceylon, he was informed that the return was 12 fold as a rule to 24 and 30 fold except in a few cases where the yield was 40 fold and this was where the fields had benefited from the washing of estates which brought down a considerable amount of well-manured silt.

The question was how to increase the yield. The ordinary villager had not the means to buy large supplies of manure, but the co-operative movement enabled him to expend a certain amount of money on manuring his fields. But they had to bear in mind that manure which was suitable for a field in Gampola was not suitable for a field in Kurunegala. Therefore, whenever, a man asked for a loan from the co-operative society for the purpose of manuring his fields, the request should be communicated to the Agricultural Department so that advice might be given on the best form of manure and the methods of manuring to be adopted.

It was most essential that the report of the Chemist should be prompt. In this way, he saw no reason why the output of paddy in many of the existing fields should not be doubled, trebled or even quadrupled. He hoped that the suggestion would be found to be practicable.

Dr. R. V. Norris, Director of the Tea Research Institute, expressed himself as doubtful as to the utility of such a procedure, and considered that the results would bear no proportion to the labour involved. He thought that, in the present state of affairs, reliable information as to the best manurial practice for paddy could only be obtained by definite manurial trials in different types of soil. The response of a soil to manures was conditioned by many factors, at present imperfectly known, and such factors were in general not capable of elucidation by mere analysis.

Mr. H. L. De Mel said that as an unofficial member of the Railway Advisory Board, he and his colleagues had pressed on the Railway to afford sufficient facilities to enable the food produce to be transported. As the Railway had been commercialised, any question of bounties and preferences was being stoutly resisted but it would interest them to hear that the last recommendation of the Board in regard to that matter had been accepted by the Government, and a rule would shortly be formulated that rice and paddy should be carried at 4 cents per ton mile for distances of 150 miles and over.

Mr. W. A. De Silva: What about short distances ?

Mr. De Mel said that the railway was of the opinion that it would be unprofitable to these commodities for short distances at the concession rates.

The Hon. Mr. E. R. Tambimuttu said that the matter of the question of freight was of immediate importance. The reduced rate applied to only a minimum of eight tons, and the small man was not benefited by it. He thought that the overhead charges on the railway was exceedingly high, and they should see that the people were not mulcted. There was a time when rice was carried free on the railway. It was not merely a question of whether it would pay the railway, but it was a question of whether it would encourage the cultivators if concessions were given.

Mr. R. C. Proctor said the statement that the villager was lazy and apathetic was far from true. The villager had been cultivating all these days for his own consumption, and if they wanted to make him an agent for extensive cultivation, they should give him all the facilities.

PADDY CULTIVATION IN CEYLON

K. KANAGASABAI

IN Ceylon fields, cultivation of cereals is neglected, and perennials, such as tea, rubber, and coconuts, are much encouraged, under the capitalist's organizations. The result has been that the country is forced to depend on India and Burma for her food supply. With the present depression in some of the major agricultural products, and with the increase of unemployment in the Island, the chances of the farmer reverting to his former position in the paddy fields, appear to be more hopeful, even though there is an impression in the minds of many that the educated youth cannot be induced to go back to the land. The most pertinent question today, that engages the minds of all those interested in the well-being of Ceylon and its people, therefore, is to find out whether paddy cultivation—the staple industry of the indigenous inhabitants—can ever be developed and set on its feet so as to make Ceylon self-supporting in the matter of her food supply.

The purpose of my paper is to invite your attention to this most important subject. In the course of it I propose to outline the present position of paddy cultivation; to examine the different systems and methods of cultivation; and to lay before you certain suggestions, which if approved and adopted, might possibly obviate the difficulties which at present hinder the progress of the paddy cultivator.

According to the latest available figures, the area under paddy is about 830,000 acres and the approximate yearly yield 13,280,000 bushels of paddy, working on an average of 16 bushels per acre. Owing to the precarious nature of the industry and to the poor yields obtained in recent years the cost of production leaves hardly any margin of profit for return on the capital invested in the land. In consequence, not only a large percentage of the holdings have changed from the original owners and passed into the hands of capitalists or money lenders, but also we are obliged to import annually nearly 15 million bushels of rice for our food.

Two methods are adopted in raising the paddy crop—one for the upland and the other for the lowland. In the cultivation of upland fields, which are generally sown for "Munmari" (pre-winter) or Maha harvest, the soil is ploughed and the caked surface is broken and pulverised so as to admit the moisture into the soil. The air within the soil also does a great deal of work. It acts like a pump, the force of which is known as capillary attraction. When the land is well tilled, the earth

forms numberless irregular hollow tubes which not only draw upwards the water beneath the surface, but also help in the formation of crumbs which provide access of free air and water to the roots of plants. Except perhaps in the Jaffna Peninsula, where the system of dry-farming is much better understood and practised in the cultivation of cereals on rainfall-fields, the scientific principles of cultivation are not adhered to by the cultivators of Ceylon owing to circumstances due partly to climatic conditions and partly to the absence of facilities for so doing.

The cultivation of lowland in the "Pinmari" (post-winter) or Yala season crop is carried on, by a process of alkaline reaction. This is specially adapted to submerged soils, where hardly any nitrification sets in but ammonification goes on to a small extent, sufficiently to supply the nitrogen need for paddy, provided sufficient organic matter is present in the soil. The organic matter is obtained by allowing the fields to lie fallow between harvests and from sediments of floods and decay of weeds or vegetable matter. Unlike the method employed in the dry-farming system, it is inadvisable in this case to plough up land and leave it exposed to sun and air, but it is important on the other hand to keep the land under water, while the necessary preparations go on for the sowing and until the water is drained for the broadcasting of the sprouted seed. The crop has then to be irrigated from time to time on a scientific basis. Any relaxation of the principles involved in the method of irrigation causes poisonous gas to emanate from the soil on the re-submergence of the land, which proves injurious to the growth of plants. In any case, however, operations are not carried out quite in accord with the dictates of science partly due to the inertia and ignorance of the cultivator, and partly to causes over which, he has no control.

Absence of the system of transplanting of paddy is a great drawback since by the adoption of the method not only the yield can be increased, but more remunerative employment can be found for agricultural labour. The general belief however is that the conditions obtaining in Ceylon are not quite favourable to the introduction of the system and I am inclined to some extent to that view. The irrigation systems in Ceylon do not, on the one hand, command a perennial source of water supply and, on the other, the requirements of water for the transplanted paddy are decidedly much more than the need of crops raised on the broadcasting system. Another disadvantage is the absence of labour in the holdings under large tanks. I am yet of opinion that at least 20 per cent. of the area might with advantage be put under transplanting of seedlings, if the scientific authorities directly concerned would only co-operate and the working of the different organizations be properly co-ordinated.

The importance of investing the Director of Agriculture with authority to guide and control the activities of the Land Settlement and Irrigation Departments, for which I have often urged, need not be lost sight of. The fact that it is the officers of the Agricultural Department, who have necessary technical knowledge and experience to advise on and formulate schemes that are essential for the advancement of paddy cultivation must be remembered. The present system of flooding fields is greatly to be deplored and much has to be done to eradicate the evil of courting plant diseases. Critics of Government agricultural policy have, however, had occasion to hurl attacks on the Agricultural Department and to find fault with the officers for not having paid the same attention to paddy as towards tea or rubber. Those statements were, I am afraid, made without an intimate knowledge that the paddy problem is a complicated one, and requires long and patient study of local conditions. Proper facilities, had not so far been offered to the Department either to go into the question of employing intensive methods, or to consider the transformation of the existing systems to new conditions, which might make the industry a paying proposition. The only work possible was pure line selection of seed to improve the variety which the officers have been carrying out satisfactorily for the last two years or so, and they have obtained much valuable information, as the Director of Agriculture has stated recently before the Legislative Council.

The transfer of the control and management of cultivation from the Irrigation Department to the Government Agents, was made after much agitation in the past, but the change has produced no benefit, since the affairs are managed on the same old lines. With the passing of the Irrigation Ordinance No. 45 of 1917 the idea was to provide an agricultural staff, under the Government Agent to be in charge of cultivation and water distribution; and that the Director of Irrigation was to confine himself to the engineering side of the work, in the collection, conservation and control of water supply as a whole in each Irrigation Scheme. The cultivators would certainly have been benefited much, under such altered conditions.

Experience has shown that the continual growing of crops on the same land without returning something in return for what the plants take therefrom thoroughly exhausts the soil. But before we go into the question of plant food, we have first to consider the various classes of Ceylon soils suited for paddy and their value for crops, judged by their mechanical texture or their chemical composition. The Department of Agriculture has therefore a good deal to do in respect of soil analysis and to decide which land requires what manure. It is a matter of common knowledge, I think, that much acidity is present in

Ceylon soils either due to weak base or to excess of organic matter; yet the cultivator is unable to treat the soil successfully as he does not know the proper material that should remove or reduce acidity.

The benefit accruing from catch, or rotation crops on paddy lands may be summarised as follows: Firstly, one of the means of retaining if not increasing the fertility of the soil is by growing leguminous plants or cover crops. Secondly, this provides additional source of income. Thirdly, it helps food production and thus increases the supply of food. Fourthly, the land is fit for the preparation of the soil for the succeeding paddy harvest without waiting for the rains. To effect any improvement on these lines, it is first necessary to keep all buffaloes and cattle off the paddy lands which now partly serve the animals as pasture, and to provide them with suitable common grazing grounds in close proximity to the fields. Under the operation of the Irrigation and Cattle Trespass Ordinances, the owners are expected to graze cattle in the daytime and kraal them at night. The success of this must naturally depend on the amount of fodder available outside the cultivated tracts. The acute distress caused by lack of food for the cattle in certain seasons of the year is indeed deplorable and is hardly realised especially when all the upland fields are in crop and the lowland is submerged in water. It is no wonder then that damage to the paddy crop by cattle is considerable and is of frequent occurrence in localities where pasture is scarce.

Latest returns shew that there are about 1,500,000 horned cattle in Ceylon. Assuming 25 per cent. of them are stall-fed, which I very much doubt, the rest will require no less than 200,000 acres of grass land. With the expansion of the powers of the Village Councils and the grant of large measures of Self-Government to them under the new Reforms in matters connected with paddy cultivation and irrigation, it should form an important duty of those bodies to see to the proper conservation and maintenance of pasture for village cattle. But it is incumbent on the present Land Commission to make adequate provision for the allotment of Crown lands for conversion into cattle pasture. The fact is that the yield from cattle is so little that stall-feeding is out of the question and the other desideratum therefore is to improve the breed.

Alienation of Crown lands by outright sales at competition was not conducive to the growth of the paddy industry. The land policy of Government shows three stages. In the first instance, extensive tracts of forest lands were sold to European capitalists for coffee planting, which was succeeded by tea, rubber and coconuts, and further impetus was given to such money crops. The second stage was the passing of the Waste Land

Ordinance, requiring lands, which were claimed by certain classes of people, particularly in the Kandyan Provinces to have their title proved. In either of the above stages no practical scheme was put forward to encourage and to expand the cultivation of paddy with the single exception of having sold Crown lands for cultivating paddy on a four years' instalment system under the wise policy initiated by the able and liberal-minded Governor Sir Henry Ward. His revered memory is ever cherished in the hearts of the thousands of cultivators in the Batticaloa District for the benevolent work he did. I am no doubt keenly alive to the need of British capital and British enterprise for the development of the agricultural resources of the Colony and to the large proportion of trade that has developed and the standard of prosperity attained by the opening up of tea and other estates. Still, for all this, it is felt that the failure to inaugurate a liberal policy of land tenure, and to aid with the necessary means for taking up cultivation, has been one of the causes that had prevented the extension of paddy cultivation. The third stage of the land policy has been worked by the present Land Commission. Though it is premature to gauge the amount of success to be obtained one thing we may be sure that so long as the Hon'ble Mr. Brayne is in touch with land development he will certainly advance the cause, since he always feels anxious for the good of the peasants.

It is gratifying to gather from the pronouncements made by the new Director of Agriculture that he recognises the importance of pushing forward both extensive and intensive methods of cultivation in the expansion and improvement of the paddy crop. He will no doubt encounter many difficulties, such as scarcity of labour, lack of capital, low prices of the produce, bad seasons, the prevalence of malaria, and in the exploration of lands which are not already opened up under large tanks. Of these the most crucial is the labour difficulty. However much one may dislike the employment of Indians for services in Ceylon, yet I am sure that the desolate regions in large tank districts, cannot be successfully brought under cultivation without settlement of colonists from India and without the aid of Indian labour. The restricted franchise Ceylon is disposed to grant to Indians and the circumstances under which the political mind of India is now smarting do not indicate great chances of the influx of Indians into Ceylon. In view of this may I put forward a practical proposal. The sheet anchor on which paddy cultivation can be improved is on the creation of peasant proprietorship. Not in the sense that it has so far been worked in Ceylon, but in the sense that the peasants will be wedded to the soil as their home. In order to materialise such a scheme not only should Crown lands be settled on them in suitable lots but agricultural implements, cattle, seed, etc., should also be provided. Cottages for

residences should be erected and all medical aid to remove insanitary conditions be rendered. A long term agricultural loan, extending to a period of about 20 years, should then be granted to those who are to become proprietors and thus enable them to open up new lands. The investment of large sums of money on such a scheme will in future years yield a good return in the shape of interest. Not only this, the country will be in a position to supply all domestic needs without being at the mercy of other countries.

It may be contended that individual ownership of lands vested in peasant proprietors may become unworkable in course of time, when the allotments are divided among members of the succeeding generations. If that is so, I propose as an alternative scheme to create a co-operative agricultural colony. Under this system, allotment of 500 or 1,000 acres may be made in common to the whole body of the colonists, under large tanks. The ownership shall remain under one unit and the working of the farms be conducted on the same lines, as at present exist, in the management and control of cultivation and irrigation of large and extensive range of paddy fields. The members of the colony can only participate in the profits of the farm but are not entitled to any division of lands under the scheme. The advantages of such a scheme are manifold. Subdivision of lands will never operate. Improved implements and modern appliances can be easily introduced. Labour-saving machinery can be readily installed. The Department of Agriculture secures a free hand to carry out experiments on a large scale and thus be able to obtain much useful data.

Now in regard to lack of capital. Sufficient inducement cannot be held out to paddy cultivators without cheap capital and easy credit. Co-operative Credit Societies are about the best organization that should to a large extent assist the cause of small cultivators. But owing to the present financial depression in the country the development of Central Banks which are necessary for the proper financing of societies may not be practical in the near future. A way to tide over the difficulty in this respect, therefore appears to lie in the early establishment of a State Mortgage Bank, which while rendering immense help to large cultivators, may at the same time further the cause of co-operative institutions even indirectly.

For the low price of produce there are obvious reasons. In the first place the cost of production is so high that we cannot stand the competition with the Indian imports. Secondly, the local varieties of rice do not cater to the demand of not only the Indian population but also of a section of the Ceylonese.

His Excellency congratulated Mr. Kanagasabai on his interesting paper and asked that any comments on that paper be reserved for a general discussion at the end of the morning session.

PADDY CULTIVATION IN CEYLON

AN ECONOMIC STUDY

SIR H. MARCUS FERNANDO, KT., M.D., B.SC.

IT was my privilege to serve on two prolonged enquiries connected with paddy cultivation in 1917 and 1918. The first one was taken on the initiative of the Agricultural Association. The second committee happened to be the Select Committee of the Legislative Council connected with the Irrigation Ordinance of 1918. During these enquiries a great deal of the ground covered by the recent Sub-Committees in various parts of the Island were gone into, and I might state at the very outset that the recent enquiry carried out in detail in every paddy growing district in the Island has only served to accentuate the findings that may have been gathered from the reports of the Committees appointed in 1917 and 1918. Early in 1919 as the result of information I had gathered I read a paper before the Agricultural Board at Kandy. That paper was reprinted in *The Tropical Agriculturist* of February 1919. Therein apart from local information I was able to obtain statistics of rice cultivation and its results in the various rice-growing countries in the world as published in a Bulletin of the Imperial Institute (April 1917). When the results of rice cultivation in Ceylon are placed side by side with those obtained in other countries remarkable evidence is afforded to show that the yield in Ceylon is the lowest in the world as the following schedule will illustrate:

Spain	101 Bushels of paddy per acre.
Japan	77 Bushels of paddy per acre.
Egypt	73 Bushels of paddy per acre.
Italy	63 Bushels of paddy per acre.
British Guiana	54 Bushels of paddy per acre.
Java	40 Bushels of paddy per acre.
India (as a whole)	30 to 40 Bushels of paddy per acre.
Ceylon	15 to 20 Bushels of paddy per acre.

This unenviable position which Ceylon holds in the rice-growing world is the main factor connected with the rice problem in this Island. I further pointed out in that paper that at that period the area under rice cultivation was given in Blue Books as 900,000 acres, and that the yield from this area was about sufficient supplemented by other food grains to furnish the rice supply of about half the population. It would thus follow that if the

yield per acre in Ceylon were doubled Ceylon grown rice would be sufficient for the food supply of its inhabitants. With a yield of 20 bushels paddy per acre as an average theoretically doubling that yield to 40 bushels—a result that would just bring it up to the conditions of India did not look very formidable. It seemed therefore that if the amelioration of the yield be energetically pursued by a co-ordinated effort between the Agricultural Department and the paddy growers a solution of the problem would be easily obtained. At any rate I pointed out that it was easier and less expensive to improve the lands already under cultivation, than to create new centres of paddy enterprise in the dry zone under major and minor irrigation works. One important reason is the fact that whenever new areas are opened up under irrigable cultivation new foci of malaria are created. The ill-health brought about in these isolated areas of cultivation become so formidable as to prevent such enterprises from being carried out to a successful issue.

Soon after this the Agricultural Department took up the question of rice cultivation in earnest, and in carrying out this policy created a new post in the Department of a geneticist for breeding better varieties of paddy. The first appointment fell to Colonel Summers, a very distinguished scientist from Cambridge. He after due enquiry early in his work made a report to Government quoting the same statistics which I had used and coming to the same conclusion—that if rice was going to be cultivated as a profitable crop readier and sooner results could be obtained by concentrating on improving the areas that are already under cultivation rather than by attempting to open up new areas in the dry zones.

I do not propose to give a sketch of the activities of the Department from that time to this but I should like to comment on some of the salient points in this report of the Sub-Committees that have recently been published. All the reports confirm what is generally known to be the fact that rice cultivation is not a paying proposition. The chief reason is, as I pointed out, the low yield per acre. Now let me restate the facts in a concrete way. With an average yield of 20 bushels of paddy the gross yield per acre amounts in money value to Rs. 40-00 when paddy commands Rs. 2-00 per bushel. Excluding the dry zone and the tank areas, there is abundant evidence in the reports to show that in the more populated and developed districts such as Colombo, Matara, Galle, etc., the individual paddy field owing to a minute sub-division of land does not represent more than an acre or an acre and a half. That is to say the gross yield of paddy cultivation in this area cannot give more than Rs. 60-00 per annum, a sum which is utterly inadequate for the maintenance of a family: so that in these districts the cultivation of paddy land is merely a

side-show to a man's livelihood. He has to earn his livelihood by some other agricultural industry or work and the paddy field is tilled during his off hours from his main occupation. In these circumstances intensive cultivation of paddy fields seems to be very remote as the inducement for efficient and continuous work is not sufficiently strong. That is a leading feature of rice cultivation in these fully developed healthy districts.

On the other hand when you come to districts like Batticaloa, Tamankaduwa, etc., under the major and minor tanks, a family can and often deals with areas of four acres or even a little more. If such an area is properly tilled and cultivated and can be depended upon year by year, a fair yield will produce sufficient rice for the maintenance of the family growing it, as well as give a sufficient margin for sale outside. With say twenty bushels of paddy per acre, a four-acre block will yield 80 bushels. With a second crop say giving 40 bushels we have a gross yield of 120 bushels of paddy equal to 60 bushels of rice. The family unit being four or even five will consume thirty bushels during the year. The balance will be the grower's money crop which he can sell outside. But does this always come about? Not necessarily. I have abundant evidence from rice growers on a large scale in Batticaloa, and from some other districts that once a man by sheer personal effort establishes a paddy field of 4 or 5 acres by his own exertion and that of his family he becomes a landlord and capitalist. He will then no longer do the manual work, but will get a tenant to do it for him. In other words this unit of 4 or 5 acres will have to support two families, that is, the family of the landlord and the family of the tenants as well, leaving nothing for sale.

There is one exception to this rule and that is in the North-Central Province and in districts where chena cultivation is extensively pursued by villagers. Here there is a surplus for export or sale and this supply emerges owing to the fact that the majority of the growers or goiyas consume the chena crops for their food, and utilise the paddy as their money crop. It is from the meagre surplus that emerges from these conditions that the export and sale of paddy and rice from the rice-growing districts is brought about.

Details in connection with paddy cultivation I do not propose to enter into as they have been dealt with very minutely in the Sub-Committees' reports, but certain important conclusions can be derived therefrom. First of all in the dry zone it is evident that it would be better to concentrate on the Yala crop and make that a success rather than attempt two crops every year, because the evidence shows that the Yala crop gives a better yield. Secondly, it is free from the paddy fly pest and thirdly, which is the most important consideration, the crop can be planted and

harvested during the period when the district is healthy and free from fever. During the Maha season some other crops might be cultivated with the natural rains as they do in Java.

Another point is that in Ceylon there is very little transplanting. Under the major and minor tanks there is none. It is all broadcast sowing; but in this there is a remarkable difference from district to district as to the amount of seed paddy used per acre. It varies from two bushels per acre in the Western Province and the Kurunegala district to three bushels in Batticaloa, and even to three and a half bushels in the Uva Province. Why should this be so ? There seems to be a remarkable waste of seed paddy in most of the districts and an attempt should be made by demonstrations carried on in various districts to reduce this waste. From my personal experience I find that one bushel broadcast is quite enough per acre. I have carried on this experiment for several years side by side with the goiya's two bushels and without any dimunition in my results when compared with the goiya's results. We are constantly reminded that the water rate under the tanks should be abolished because the cultivation does not pay. Even if one bushel of seed paddy be saved from each acre that saving will cover the water rate levied in most cases.

Another very important factor, a matter which is touched upon in the various reports, is the complaint that a great handicap towards successful operations in paddy cultivation is deficiency of cattle suitable for agricultural purposes and the blame is attributed to the want of natural pasturage. Now, this problem has to be approached from a different angle of vision. Those who complain that there are not enough cattle to go round in a particular district do not seem to have taken into account the actual number of cattle that are present in the district, nor do they make a proper estimate of the actual cattle needs of the district. The best cattle district in the Island is the Kurunegala district. Cattle are more plentiful here than in any other part of the Island. The cattle population consists of 167,000 buffaloes and 224,000 neat cattle. The acreage under paddy amounts to 134,000 acres, so that you have for this area something like three head of cattle for each acre. This is a very generous proportion and the question arises that even with three animals in the district for each cultivable acre how can the complaint arise that there are not enough cattle for paddy cultivation. The explanation is the same as the one emphasised by the Royal Commission on Agriculture in India in their report. India is a country where cattle are better looked after, fed on fodder that has been carefully grown and cultivated for the dry season, and where cattle are used for ploughing and for well-irrigation. Even with animal husbandry so developed the Commissioners in their report say:

"There would, in fact, appear to be an excess in the numbers of the cattle necessary for cultivation if these cattle were efficient. The figures suggest the existence of a vicious circle. The number of cattle within a district depends upon and is regulated by the demand for bullocks. The worse the conditions for rearing efficient cattle, the greater the numbers kept tend to be. Cows become less fertile and their calves become undersized and do not satisfy cultivators who, in the attempt to secure useful bullocks, breed more and more cattle. As numbers increase, or as the increase of tillage encroaches on the better grazing land, the pressure on the available supply of food leads to still further poorness in the cows. As cattle grow smaller in size and greater in number, the rate at which conditions become worse for the breeding of good livestock is accelerated. For it must not be supposed that the food required by a hundred small cattle is the same as that needed by fifty of double the size. As cattle become smaller, the amount of food needed in proportion to their size increases. Thus large numbers of diminutive cattle are a serious drain on a country in which the fodder supply is so scarce at certain seasons of the year as it is in India. The process having gone so far, India having acquired so large a cattle population and the size of the animals in many tracts having fallen so low, the task of reversing the process of deterioration and of improving the livestock of this country is now a gigantic one; but on improvement in its cattle depends to a degree that is little understood the prosperity of its agriculture and the task must be faced.

"Unless substantial changes in the existing management of cattle are introduced, a progressive deterioration in the quality of the cattle is to be feared. Four cardinal points in a policy of improvement must be (a) a reduction in the number of plough cattle; (b) an increase in the efficiency of plough cattle; (c) attention to all matters that would tend to decrease the number of bullocks required for cultivation; and (d) an effort to secure better treatment for dry cows and cows in-calf."

This serious state of affairs is even more pronounced in Ceylon than in India. What we should aim at is a much smaller number of efficient useful cattle rather than many ill-cared, and underfed and dimunitive cattle which is the result of the vicious circle so vividly described in the previous paragraph.

The present state of affairs cannot be remedied except by introducing a system of animal husbandry based on scientific principles. At present, as far as the small cultivator and even coconut planters are concerned, there is no attempt to maintain the breeding of efficient cattle on a practical basis. But on the other hand, the cry is for alienation of land for pasturage purposes by Government. The enormity of this problem, so far as I can remember, has never been put into a concrete form. I will

take this one district, Kurunegala. To maintain 391,000 head of animals which at present roam about the district the pasturage area that will be required even on the modest basis of two acres to each animal will amount to something like 800,000 acres. One has only to state the problem in that form to show how impracticable it is. Is it suggested that Government should alienate 800,000 acres in one district for this immense cattle population ? As a matter of fact the total acreage under cultivation in the Kurunegala district amounts to about 400,000 acres in coconut, paddy and other crops; and yet if pasturage is to be found double this area will be required. The fact of the matter is that a fourth of the animals that now exist will quite suffice for the cultivation requirements of the district. It is only by the reduction of the animals that are now there and by careful pruning and weeding of the useless and the unfit and the careful selection of bulls and buffaloes for stud purposes that an efficient system of implemental cultivation by animal power can be maintained.

I have already referred to the important question of the minute subdivision of paddy fields. The conditions of inheritance in this country are such that the minute subdivisions that now exist cannot be remedied by any simple means of legislation. But alienation in the future of Government lands should tacitly provide for the prevention of subdivisions below an unit necessary to maintain a family. In all future alienations it would be well for Government to impose conditions that would prevent such a subdivision. It was proposed some years ago to fix the smallest unit that is economically sound to four or five acres of paddy land, and perhaps double that acreage of high land. In future alienations such blocks, and such blocks only, should be sold with the proviso that the blocks could not be transferred or sold in part or inherited in part.

Lastly, I should like to touch upon another aspect of the problem—an aspect which concerns the future food supply of this country. I have on more than one occasion emphasised elsewhere the fact that the opening up of land in the dry zone through paddy cultivation is an impossible task, and one which instead of diminishing malaria will tend to increase it to an inordinate extent. Two years ago an important and weighty report by a Commission appointed by the League of Nations on the subject of malaria prevention was issued. This report is all the more interesting to us as the Commissioners were specifically enjoined to investigate measures appropriate in countries where the cost of public health is an important consideration. The Commissioners state that the history of special anti-malarial campaigns is chiefly the record of exaggerated expectations followed sooner or later by disappointment and the abandonment

of work. In Europe the correct anti-malarial practice is an endeavour to reduce the incidence and severity of the disease. Measures designed to accomplish more than this, that is eradication, can only be justified under very exceptional circumstances. The Commissioners report that in the different countries they visited in the Middle East only two regions were found in which drainage and similar methods of an expensive nature were found to be successful. The first is Dalmatia amongst the dry and waterless hills with a meagre rainfall. The second place where anti-larval measures gave perfect results was Palestine. In the larger towns the water supply was dependent on cisterns and the anopheles mosquito was found to breed in these cisterns and that was the only cause of malaria in the town. The cisterns were closed and provided with hand pumps and malaria was reduced to almost nothing. The conditions in Palestine are specially suitable for anti-larval measures. The mountains are dry, the valleys are easily drained, and what is more there is no rice cultivation. How then are the dry zone areas which represent more than one half of the Island to be developed and opened up ? They should be dealt with in the same way as our experience shows how malaria has been reduced and lessened in such districts as Negombo, Chilaw and the adjacent country. The wide extent of coconut cultivation leaving very little intervening unopened tracts and the improvement in the standard of living which this cultivation has affected in the population in the districts involved has been the potent cause of the health improvement. The opening of the Kelani Valley and Kalutara in tea and rubber thirty years ago was associated with a high malaria outburst. In one large estate in the Kalutara district the death rate among coolies amounted to 500 per thousand in one year but the continued cultivation of extensive clearings without any special measures have rendered the malaria incidence anything but serious at the present time. This is the only way the problem of the dry zone development can be tackled; by bringing under cultivation the highlands first and to leave the irrigable lands to be dealt with later. Highlands require for their successful cultivation efficient drainage and the drying up of swamps—not their creation as in rice fields. The development of these lands means the gradual disappearance of malaria and the reduction of its severity. But to effect such a "bonification" scheme there is one indispensable condition. It is necessary to discover a system of agriculture whereby these lands can be profitably cultivated. This is a necessary corollary which must find solution either through Government initiative or through private enterprise. Hitherto private enterprise in agriculture has been practically confined to the wet zone, but signs are not wanting that such a concentration of enterprise cannot proceed much longer, and private initiative must go farther afield.

Such permanent crops as sisal, kapok, sugarcane, oil palm and others suited to general farming, such as maize, millets, soya beans, cotton, tapioca, sesame and the various pulses, together with cattle breeding and animal husbandry open out a wide field for enterprise and initiative. Most of these products the Right Hon'ble Ormsby-Gore informs us are grown extensively in similar lands of Java. All of them are grown in India and in other tropical and sub-tropical countries of Europe, Africa and in North and South America.

I admit that the problem is not a simple one and its solution may take a long time, but I feel confident that the attempt to populate these areas through rice cultivation is entirely wrong—it only adds fuel to the fire of malaria production. It is only through opening up the higher lands with ordinary farming or through permanent crops, that we can ever hope to obtain a settled population and a prosperous and healthy countryside.

The way indeed is a long and weary one, but I am confident that the combined efforts of a far-sighted Government and the ingenuity and enterprise of our leaders in agriculture will end in solving the problem successfully.

DISCUSSION

His Excellency thanked Sir Marcus Fernando for his very interesting and comprehensive paper and said that there was much food for thought therein. He now invited general discussion upon what they had heard during the morning.

Rev. J. R. Tambimuttu emphasized the necessity of inducing people who had not hitherto interested themselves in the actual cultivation of paddy to take up this industry. He mentioned, for instance, the Veddahs, who are mainly occupied in chena cultivation. He said that with the assistance of Mr. Brayne, he was able to establish a colony of Veddahs who were induced to take to paddy cultivation. Why should not the planters take up paddy cultivation ? He had the opportunity of discussing the subject with a good many of them, and they told him about the failure of the Minneriya Scheme, and of the uneconomic aspect of the business. He suggested that lands should be granted to planters on easy terms as an inducement to them to take up this industry. He said that he was earnest in what he said and commended the suggestion for the consideration of the Government.

Mr. R. C. Proctor disagreed with Sir Marcus Fernando's suggestions with regard to pasture lands.

Mr. J. C. Ratwatte Adigar agreed with Sir Marcus Fernando's suggestion to increase the yields. They had the unenviable reputation of producing the lowest yield in the world. Obtaining of increased yields in areas that were already under cultivation should be their aim. Speaking on Vel Vidanes, to whom Mr. W. A. De Silva had alluded in his paper, the Adigar said that these headmen should go to the villagers as their friends, and co-operate with them in their work. At present there was no co-operation between the Vel Vidanes and the cultivators. He also suggested the introduction of hulling machinery that could be used by the villager. At present, rubber landowners were prepared to give up their lands, and Government might perhaps acquire some of these, for pastures for the benefit of the people.

Dr. Youngman said that if they studied the yields of paddy in different countries in the world, one thing that would strike them as extraordinary was that highest yields were obtained in lands where highest wages were paid and where highest expense was made on cultivation. That was a point which made one seriously to think. In the order of paddy cultivation, Spain came first, Japan and Egypt came second, and India and Ceylon came last. To say that because the cost of production here was higher than elsewhere, they could not compete with other countries was not quite justified. A great deal had been said about agricultural instruction in Ceylon.

What they should do was to make agricultural instruction in villages more extensive. He was a villager himself, and he was brought up in a small village. He agreed with those who said that they had a great deal to learn from the villagers. The influence of the Agricultural Instructors should carry the scientific methods into the villages. The next thing he wished to refer to was irrigation and he thought that it was a matter to which they should seriously pay their attention, and if they had been mistaken in the past in this matter, they should approach the subject with a new angle of vision. A peculiar difficulty in Ceylon was that a variety of paddy that grew on one side of the hill did not grow on the other side. Perhaps it would be advisable to tackle the larger districts first where a more uniform variety could be grown. A great deal had been done in the separation of varieties, and the more he examined the work in that direction, the more he saw they were proceeding on the right lines.

He saw before them that day representatives of two of the largest firms of fertiliser manufacturers in the world. With regard to fertilisers he could say that generally in Ceylon nitrogen and phosphorus were the elements requird in fertiliser compounds for paddy.

He was also of the opinion that condition of tenancy could be improved, and, in doing so, he was sure that they would be able to adjust matters without being unfair to the landlord. Landlords in Ceylon, he hoped, would be patriotic enough to see that it was to everyone's advantage to increase the yield of paddy and he believed they would help the cultivators to achieve such increase in the Island.

THE CURING OF SHEET RUBBER

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SMOKED sheet has been one of the two standard grades of rubber prepared on estates for a number of years. The practice of smoking sheet rubber probably originated from a desire to imitate the smoking process used in the Amazon valley for the preparation of "fine hard para," but has been continued mainly because it provides such a convenient method for drying the rubber. It has been recognised for some years both in Malaya and Ceylon that firewood reserves were being depleted, and in some of the older planting districts of Ceylon there has recently been a definite shortage leading to a material increase in the price of firewood. The position regarding the utilisation of wood in the rubber industry in Malaya was investigated by B. J. Eaton in 1924 at the request of the Malayan Government (1) and suggestions were made for alternative methods of curing rubber. In Ceylon the attention of the Rubber Research Scheme was also drawn to the subject by Mr. A. T. Sydney Smith at about the same time. The experiments which are to be described in the present paper were undertaken with a view to devising a method for curing sheet rubber which would either eliminate the use of firewood altogether or reduce the amount required to the greatest extent possible.

It is to be noted that the position regarding supplies of firewood may be entirely altered in the next few years if replanting of old rubber areas is taken in hand to any great extent. In this case supplies of firewood would be assured for many years to come, as replanting programmes would doubtless be spread over a considerable period.

REASONS FOR SMOKE-CURING

In the first place it is desirable to consider the purpose which is served by smoking in the preparation of sheet rubber. Dr. De Vries, late Director of the Proefstation voor Rubber, Java, stated some years ago in a publication (2)

"According to the present state of our knowledge one can see two outstanding advantages in smoking:

1. It acts as a disinfectant and therefore decreases the susceptibility to moulds; perhaps it may also help somewhat in preventing rustiness.

2. It makes the colour of the sheets more even and uniform, since the quickly arising differences in tint in unsmoked sheet are levelled up or made invisible by it, whilst the spots caused by oxidation (violet discoloration) of the coagulum are more or less made to disappear. In fact the smoke as a "cloak of charity" covers many irregularities in the "exterior." To this Dr. De Vries would no doubt agree to add that it forms a convenient means for supplying heat to dry the rubber.

B. J. Eaton [3] gave the following definition: "The smoke-curing of sheet rubber is a method of rapid drying combined with absorption by the sheet of creosotic and other antiseptic substances from the smoke, which substances prevent or reduce the development of moulds (fungi) and other micro-organisms."

Sidney Morgan [4] stated "Broadly the process is akin to the smoke-curing of herrings and the objects are much the same, viz. (1) Drying, (2) Preservation—except that while herrings are only dried partially, rubber should be dried perfectly."

UNSMOKED SHEET

Considering the functions of smoking which have been established above, namely, (1) drying at raised temperature, (2) disinfection, (3) masking of irregularities in appearance, it seems reasonable to suppose that means could be devised whereby the smoking process could be eliminated. As regards drying, there is no technical difficulty in heating a drying room for the rubber either by means of air passed through a heating chamber by means of a fan, or alternatively by radiation from steam pipes. The latter system is considered most suitable as only a slow current of air is required and the use of power for driving the fan is eliminated. The boiler or heater may be fired either with coal, coke or fuel oil; which is cheapest to use being mainly dependent on transport. In the case of fuel oil, power is required to drive a blower for the burner. This system of heating would have the advantage of cleanliness and the temperature of the drying room could be more closely controlled than can be done in an average smokehouse.

Passing to the second function of smoking, namely, disinfection, it is known that whereas wood smoke retards the development of mould on sheet rubber it is by no means a perfect disinfectant, and smoked sheet is liable to develop mould if it becomes damp during transport or storage. On the other hand sheet rubber can be made extremely resistant to mould growth by treatment with paranitrophenol (P.N.P.). As far, then, as disinfection is concerned it appears that the work can be done more effectively by other means than by smoking.

As regards the obscuring of irregularities in the colour of the sheet, discoloration of the coagulum can be prevented, if

considered necessary, by addition of a very small amount of formalin to the latex (1 part formalin to 1,200 parts dry rubber). Specks of grit and other blemishes are much more readily observable in unsmoked sheet, but it would be all to the good both of Producers and Manufacturers if the preparation of this grade of rubber led to greater cleanliness and to an improvement in methods for straining the latex. Alternatively if considered desirable, the colour of smoked sheet could be simulated by addition of a small proportion of a phenolic substance to the latex with the coagulant.

Experiments were carried out on the lines suggested above; in the first place on a small scale, the sheets being dried in a small heated cupboard and later in a "half scale" building heated by means of steam pipes. This building was designed on orthodox smokehouse lines, the dimensions being 10 ft. by 10 ft. by 14 ft. high (at the ridge). Steam was generated in a small vertical boiler, the radiating surface being provided by means of 100 ft. of 2-in. steam piping situated about 6 inches above the floor of the building. Four tiers of racks were provided for hanging the sheets, the total capacity being approximately 825 lb. Ventilation consisted of four 6-inch inlet pipes near the base of the building and two 6-inch chimneys in the ridge. The remainder of the roof was sealed with asbestos cement sheets, and doors and windows were made to fit closely.

The experiments indicated that sheet rubber dried without smoke at a normal smokehouse temperature, namely 115°F, is distinctly soft and sticky. It was found advisable to reduce the drying temperature to 100°F and even when dried at this temperature sheets had a characteristic surface stickiness which is not present in average smoked sheet. Closer examination of sheets airdried at ordinary temperature showed that they too, at least at certain times of the year, were slightly sticky compared with smoked sheet. The stickiness of different samples was compared by determining the weight required to peel two strips apart after they had been pressed together under a 14-lb. weight. This may be regarded as a measure of "massing effect" and did not always correspond with the apparent stickiness as judged by touch. Typical results from the tests were:

	Weight required to separate two pieces.
Smoked sheet ...	20 - 100 grams
Sheet airdried at ordinary temp.	100 - 250 ,,
Sheet airdried at 100°F ...	250 - 750 ,,

The stickiness did not appear to be influenced by the presence of paranitrophenol or by the amount of washing after rolling, but addition of hydroquinone (1:2,000) to the latex slightly reduced

the stickiness of the rubber. The method of preparation which was finally adopted was to airdry at ordinary temperature for about 6 days and complete the drying at 100°F.

London brokers to whom samples were submitted made no reference to stickiness in their valuation and the London Committee of the Research Scheme also regarded the stickiness as unimportant. It is probable that the stickiness had actually diminished or disappeared by the time the samples reached London as it can be demonstrated that this occurs when unsmoked sheet rubber is cooled in an ice box. It was however considered that the stickiness of unsmoked sheet would prove a distinct drawback to its sale on the local market and might result in undue massing of the rubber during transport.

From the experimental results recorded above it appears that smoke curing serves a further important purpose in addition to those which have previously been recognised, namely, it enables sheet rubber to be dried at raised temperature without becoming sticky. The following points in connection with the effect of smoking on stickiness have been established: (a) sheet dried in smoke is not normally sticky; (b) sheet dried without smoke is sticky; (c) sheet dried without smoke and afterwards smoked loses its stickiness to a substantial extent; (d) sheet dried in smoke and afterwards exposed to hot air does not become noticeably sticky.

It is known that raw rubber is sensitive to oxidation especially at increased temperature, and it is probable that the stickiness of airdried sheet is partially due to oxidation of the caoutchouc. Partially, however, it is thought to be due to the drying of serum substances on the surface of the sheet. The mechanism of the action of smoke in preventing stickiness has not been carefully investigated as it was considered more important, for the purpose of this investigation, to concentrate for the present on results rather than on the precise reason for them. It is quite feasible that wood smoke contains small quantities of some anti-oxydant substance which prevents oxidation of the rubber during drying and that this is assisted by the presence of carbon monoxide and carbon dioxide. Mainly it is considered that the action is that of a lubricant or varnish, smoke constituents being deposited on the surface of the sheet and masking the stickiness caused by oxidation of the rubber or the drying of serum substances. That this is the case is shown by the fact that unsmoked sheet partially loses its stickiness if subsequently smoked. Also the smoke may serve a purpose in sealing the surface of the rubber so that serum substances are not exuded during drying.

So far the question of unsmoked sheet rubber has been dealt with from the point of view of appearance, but the greatest drawback to the development of this type of sheet as a standard market grade arises from examination of the internal properties of the rubber. Numerous samples have been forwarded to the London branch of the Research Scheme at the Imperial Institute for examination and, as the result of a lengthy investigation, it has been established that unsmoked sheet, containing paranitrophenol as a disinfectant, is inferior in ageing properties after vulcanisation to smoked sheet. This means that rubber articles prepared from unsmoked sheet would perish more quickly than those made from smoked sheet. Sheet airdried at normal temperature is superior to sheet dried at raised temperature. Sheet which has been airdried and afterwards smoked has satisfactory ageing properties.

The conclusion regarding the inferior ageing properties of unsmoked sheet must be qualified by saying that all the samples which were examined contained paranitrophenol. Some samples of airdried sheet, without P.N.P., examined some years ago in connection with another investigation were reported to have good ageing properties, and it is therefore at least possible that the deterioration is connected with the presence of P.N.P. Samples for the elucidation of this point have been forwarded to London and it is hoped that preliminary results will be available for presentation with this paper.* If it is confirmed that unsmoked sheet is inherently inferior in ageing properties, any thought of developing a market for this grade of rubber must be given up. If, on the other hand, the deterioration is found to be due to the presence of P.N.P., then the subject remains open for further investigation. The following must be added to the functions of smoke-curing: Smoking improves the ageing properties of sheet rubber or alternatively neutralises the influence of paranitrophenol which tends to cause deterioration.

SMOKING IN ROOM HEATED BY STEAM PIPES

Having shown that there are sound reasons for retaining the smoking process in the preparation of sheet rubber, attention was turned to a proposal made by the writer in a report on airdried sheet prepared several years ago, namely, that heat for drying the rubber should be provided by means of steam pipes, smoke being generated at the same time by slow combustion of wood under the most economical conditions. In experiments some years ago on the influence of different types of smoke in preventing mould in sheet rubber[5], "uncombusted" smoke, as it was termed, was produced by slow combustion of wood in a small

* A cable received from the Imperial Institute indicates that a sample of unsmoked sheet without P.N.P. was found to be superior in ageing properties to a sample containing P.N.P. which was prepared from the same batch of latex.

drum (5-gallon capacity) with ventilation holes at the bottom and fitted with a perforated lid. It was known that by this means a large volume of smoke could be produced with a low consumption of wood.

A quantity of smoked sheet was prepared in the experimental drying house by this method. Heat for drying was provided by the steam pipes (steam pressure 25 lb. per sq. inch). Smoke was generated by combustion of rubber firewood in the 5-gallon drum referred to, which gave an ample volume of smoke; the problem being rather to restrict the amount than to augment it.

The sheets were attractive in appearance. They were perhaps slightly more sticky than normal smoked sheet, and had a slightly clammy feel which is not present in the highest grade sheet. This was considered to be attributable to rapid smoking and to the type of smoke produced by slow combustion.

The rubber, amounting to approximately one ton, was sold in Colombo where it secured full market price. The broker's report was as follows:

FIRST CONSIGNMENT

Grade	*Character*	*Colombo valuation*
Dark sheet } Lighter sheet }	Strong evenly smoked good quality	24½ cents
	Market price for day	24½ cents

Remarks.—Both these samples are standard quality sheet and we would give the preference, if any, to the more lightly smoked sheets. The smoking in both cases is satisfactory.

SECOND CONSIGNMENT

Grade	*Character*	*Colombo valuation*
Ribbed smoked sheet	Strong good quality sheet, little unevenly smoked	22½ cents
	Market price for day	22½ cents

During the time that the smokehouse was filled with rubber, firewood consumption amounted to 43 lb. per day (20 hours' smoking). Allowing 8 days for drying and smoking (it will be shown later that the time of smoking should not exceed 5-6 days) the actual consumption of firewood for smoking amounted to 1 lb. of firewood to 2·4 lb. rubber, or in other words 1 "yard" of firewood to 1,350 lb. rubber. This, it should be remembered, was in the experimental smokehouse holding only 4 tiers of sheets. In a modern estate smokehouse containing 12 tiers of sheets, and allowing for the fact that the rubber was somewhat too heavily smoked to suit the Colombo market, the consumption should not exceed 1 yard to 2 tons of rubber.

Condensation of water in the steam pipes averaged 35 gallons per day, which represents in an efficient low pressure boiler a consumption of 35-40 lb. of coal. Taking the price of coal at Rs. 30-00 per ton and firewood at Rs. 2-50 per "yard," the cost of fuel for drying and smoking amounted to 0·65 cents per lb. of rubber. If, as in subsequent experiments, the time of drying and smoking was reduced to 6 days by suitably regulating the thickness of the sheets, the cost would be 0·49 cents per lb.

This, then, constitutes a method whereby an estate faced with a shortage of firewood supplies may continue to produce standard quality smoked sheet, without increase in cost of production and with very materially reduced consumption of firewood; but the question arises whether some means of heating the building could be devised which would dispense with the need for a somewhat costly boiler and steam pipe installation.

SMOKING IN ROOM HEATED BY COKE STOVE

Some years ago the question of heating by means of a coke stove was considered, but preliminary tests did not give promising results and this line of work was not followed up. Recently, however, Mr. R. C. Barnacle, Superintendent of Sunderland Estate, submitted to the Research Scheme samples of smoked sheet which had been cured in a smokehouse heated by a coke fire, and which were very satisfactory in appearance. Samples which were forwarded to London for vulcanisation tests, together with normal smoked sheets made from the same batch of latex, were found to be excellent in quality. Referring to ageing properties the preliminary report states: "The sheet smoked over burning coke is slightly superior to ordinary smoked sheet. The difference is not sufficiently marked to be of great interest." Plasticity and rate of vulcanisation were approximately the same as that of the control sheets.

A test of this method of curing was made in the experimental smokehouse. Heat was provided by means of coke burned in a small green-house stove. Smoke, as in the previous experiments, was generated by burning rubber wood in a 5-gallon oil drum fitted with a perforated lid. Approximately ½-ton of rubber was prepared, the time of smoking being 5-6 days. The sheets were attractive in appearance, but had the slight clamminess which was referred to previously. The rubber is being forwarded to London for disposal but samples were submitted to a firm of brokers in Colombo whose report was as follows:

Grade	*Character*	*Colombo valuation*
Diamond smoked sheet.	Strong, evenly smoked good quality sheet	-/17 cents
	Market price for day	-/17 cents

Remarks.—All six samples represent good standard quality smoked sheet and are all of equal value. The only preference there might be is that we should make the darkest smoked sheet of sample No. "A" the best of the lot while all three samples marked "A" are better rolled than samples "B."

There was a slight tendency for dust to rise in the smokehouse when the stove was being raked out, but this is probably no worse than in a normal smokehouse, and was obviated in the experiments on Sunderland Estate by cleaning the stove from outside the building. When the smokehouse was heated by steam pipes the temperature could be regulated to 1-2°F. In the case of coke heating the variation amounted to 4-5°F which represents considerably closer control than is usually attainable in a smokehouse.

Fuel consumption during the experiment averaged 41 lb. of wood and 40 lb. of coke daily (20 hours' smoking). On the basis of 6 days' smoking this is equivalent to 1 lb. of firewood to $3\frac{1}{3}$ lb. rubber or 1 "yard" to 1875 lb. rubber. In a full size modern smokehouse it should be practicable to smoke $2\frac{1}{2}$ tons of rubber per yard of firewood. Taking the cost of coke at Rs. 25-00 per ton and firewood at Rs. 2-50 per "yard" the actual cost of drying and smoking in this experiment amounted to 0·43 cents per lb. of rubber. The cost is very similar to that entailed by steam pipe heating but the need for an expensive installation is eliminated, and it is considered that the product is slightly superior in appearance.

It is difficult to compare these costs with the cost of smoking over a wood fire. Mr. Barnacle considers that a saving of 50% can be effected by the use of coke for heating, but in the writer's opinion this depends on the type of fire which the coke stove replaces. If the wood has been burned under optimum conditions there should be little difference in cost with firewood at Rs. 2-50 per yard. If on the other hand a wasteful type of fire is replaced by the well-controlled combustion of a coke stove, then there may well be a very material saving. The curing of sheet rubber in a building heated by a coke stove, in the presence of smoke generated by slow combustion, can be regarded as a thoroughly practical method for the preparation of standard smoked sheet with greatly reduced consumption of firewood, and may also prove more economical than normal smoking.

The foregoing conclusion is subject to confirmatory tests of the quality of rubber smoked over a coke fire.

PRELIMINARY AIRDRYING

The writer has recently made a suggestion that sheets (containing P.N.P. as a disinfectant,) could be partially airdried at ordinary temperature before smoking, with proportionate

economy in fuel. The question of the rate of drying of sheet rubber at different temperatures will be considered later in the paper but it may be mentioned here that in a recent experiment sheets (containing P.N.P. as a disinfectant) were airdried for 6 days and were then transferred to the coke heated smokehouse for 3 days for smoking and completion of drying. The amount of smoke was increased somewhat to give the required depth of colour, but this did not materially affect the consumption of firewood. The cost of curing was therefore slightly over 0·2 cents per lb. to which must be added the cost of paranitrophenol amounting to 0·17 cents per lb. The sheets were submitted for valuation in Colombo with the other sheets cured over coke and the broker's report covers both samples (sample B partially airdried).

In some earlier tests partially airdried sheets which were smoked in the room heated by steam pipes were slightly sticky, but it is not certain whether this was due to the method of heating or if the tendency to stickiness varies at different seasons. It should also be mentioned that samples which were prepared soon after new tapping cuts were opened were somewhat "short," but this was probably insufficient to affect the value of the rubber. It remains to be proved whether preliminary airdrying will lead to any economy compared with continuous smoking under optimum conditions, but several managers of estates with comparatively inefficient smokehouses have reported a material saving by adopting this method of curing.

That concludes the account of the experiments on alternative methods of curing sheet rubber, but the opportunity will be taken to discuss several questions relating to design of smokehouses and the properties of sheet rubber which have been considered during the course of the investigation.

SMOKEHOUSE DESIGN AND VENTILATION

It is now generally recognised that economy in smoking is largely dependent on the amount of rubber which can be accommodated over each fire, or in other words on the height of the smokehouse. It is necessary that both heat and smoke should be utilised to the best advantage before they pass from the building, the limiting factors being the fall in temperature which occurs as the smoke ascends and the humidity of the air. It is considered that an efficient smokehouse should accommodate at least 12 tiers of sheets, which implies a building of 3 storeys including the ground floor, approximately 30 feet in height. Several such smokehouses have recently been constructed in Ceylon and their introduction has largely been sponsored by Mr. L. M. W. Wilkins. In a smokehouse of this type firewood consumption should not exceed 1 lb. to 2 lb. of rubber, *i.e.*, 1 "yard" to ½-ton of rubber, and in at least one case a considerably higher output has been obtained.

Efficiency must also depend very largely on the ventilation of the building, it again being a question of making the best use of heat and smoke before they pass from the building. In a publication on smokehouse design[6] the need for adequate ventilation was stressed and it is well known that lack of ventilation may lead to trouble with "rust," or alternatively may cause the sheets to "sweat." When a fire is burning in a room, however, a considerable draught is produced and large quantities of air are drawn through comparatively small openings, and the amount of ventilation must therefore be very carefully regulated. Up to the present smokehouse ventilation has been entirely dependent on personal judgment, but the opportunity has been taken to make measurements of air movement in the experimental smokehouse. The volume of air passing out through the top ventilators was carefully measured by means of an air-meter and, with the amount of ventilation provided, it was found that air movement (at a temperature of 115°F) was equivalent to 5-6 complete changes of air per hour. A similar test with the door of the lower room open showed no increase in the amount of air passing through the top ventilators. This is taken to confirm the opinion that ventilation should mainly be controlled by restriction of top ventilation. If, on the other hand, free top ventilation is provided and the flow of air is restricted from the bottom, then, when the door is opened for stoking the fire, there is an immediate rush of air through the building. Tests of the humidity of the air leaving the building, even under adverse conditions, showed it to be only 60% saturated with moisture, and it was therefore concluded that ventilation was ample. It was concluded that smokehouse ventilation should approximate to 1 sq. foot of top ventilation to each 3000 cubic feet capacity of the room, and one sq. foot of bottom ventilation to 1500 cubic feet capacity. Naturally in designing a new building provision would be made for additional ventilation and a final adjustment made according to results.

RATE OF DRYING OF SHEET RUBBER

The rate of drying of sheet rubber is a matter of considerable interest. Freshly rolled sheet after being allowed to drip for a few hours contains approximately 25% of moisture. After one night in the smokehouse the moisture content is reduced to 5% and after 2 nights to 2%. It is the small proportion of residual internal moisture that remains at this stage which is so difficult to remove and which really regulates the time required for complete drying. If the sheet is hung to airdry at ordinary temperature the moisture content is reduced to 15% after the first night, to 5% after 2 days, and to 2% in 3-4 days. The bulk of the moisture can thus be removed without artificial heat and it is only for the last stages of drying that heat is really required. In a recent

experiment, sheet (containing paranitrophenol) which had been airdried for 6 days was completely dry in $1\frac{1}{2}$ days after transfer to the smokehouse; although it required a further $1\frac{1}{2}$ days before it was sufficiently coloured. Similar sheets put straight into the smokehouse required 5-6 days for complete drying. From the fact that most of the moisture is removed during the first night of smoking it follows that, if a separate auxiliary smokehouse is provided for the first night's smoking, the ventilation of the main smokehouse could be materially reduced, in fact, it could be regarded more as a smoke room than a drying room. Tests on these lines may lead to a standard of fuel economy which is not at present attainable.

The rate at which the residual internal moisture present in the sheet can be removed depends mainly on the thickness and texture of the rubber. Careful tests have been made of the effect of the thickness of the sheet on the rate of drying and it is concluded that in most Ceylon estates the sheets are too thick for efficient drying. An average Ceylon sheet may be taken as weighing $1\frac{1}{2}$ lb. and having dimensions of 23 in. × 15 in. This corresponds to a weight of 10 ounces (280 grams.) per sq. foot. Such a sheet takes 7-8 days to dry in the experimental smokehouse. By reducing the thickness of the rubber to 8-9 ounces (225-250 grams) per square foot the time required for drying can be reduced to 4-6 days in the experimental smokehouse. A sheet weighing $1\frac{1}{2}$ lb. and measuring 23 in. × 18 in. is of correct thickness for efficient drying combined with good appearance, and is also the most suitable size for packing in a standard rubber chest. Admittedly under estate conditions it is not easy to make sheets of these dimensions in the coagulating pans which are in use (10 in. × 14 in. and 11 in. × 16 in.), also in many factories sheeting rollers are insufficiently wide (20 in. instead of 24 in.) and the reapers in the smokehouses are not suitably spaced. In such cases it is desirable that the correct thickness should be ensured by making a sheet of somewhat smaller weight.

It is usually the ends of the sheet which take longest to dry owing to the coagulum "banking up" at the ends during rolling. This can largely be avoided by hand pressing the rubber before rolling and at the same time the shape can be influenced to produce a wider sheet. Mainly it is thought that the slower drying at the ends is due to increased thickness but it may also be due to the rubber being pressed harder. Careless handling of the coagulum or unevenness of the rollers may also lead to thick patches which delay drying.

Some tests have been made with a view to designing a coagulating pan of more suitable size than those at present in use. A pan is exhibited having the dimensions: top 13 in. × 15 in., bottom 10 in. × 12 in., thus giving well-sloped sides and ends. Latex

coagulated in this pan can be rolled, without previous hand pressing, to give a sheet of correct dimensions for the packing chest and free from slow drying ends.

In designing a smokehouse the size is usually based on an allowance of 10 days for smoking and drying. If the thickness of the rubber is suitably controlled there is no reason why the smoking period should not be reduced to 6-7 days with consequent reduction in capital expenditure and operating costs. Smoking should be continued for 18-20 hours daily which leaves ample time for sorting and removal of sheets. It is fallacious to suppose that smoking should be discontinued in the daytime in order to get the benefit of the heat of the sun. The day temperature of a smokehouse, without fire, is rarely above 90°F, and this temperature does little to assist in removal of the residual moisture referred to. On the other hand a small fire will raise the temperature to a useful level. No comparative experiments have yet been made on the effect of temperatures above 115°F on rate of drying, although there are indications that a temperature of 125-130°F may give a substantial reduction in time of drying. The disadvantage of increasing the temperature in an estate smokehouse is the increased risk of fire.

HANDLING SHEETS: PATENT CLIPS: THE DEVON SMOKEHOUSE

During the investigation of smokehouse design the writer has been impressed with the inconvenience of the usual type of building from the point of view of handling the sheets. Placing the reapers at right angles to the passages and providing loose reapers, so that the position of the sheets can be altered without handling, has been advocated, but even this method has its disadvantages as there is a tendency for the ends of the sheets to stick together if the reapers are closely spaced. Recently several patent clips for hanging sheets in the smokehouse have been placed on the market, the chief advantages claimed being that the sheets are kept free from reaper marks and need not be handled during the smoking period. The disadvantage is that the strip of sheet held by the clip, amounting to about $2\frac{1}{2}$% of the total weight, is not smoked and must be cut off. The writer's experience is that a $1\frac{1}{2}$ lb. wet sheet when held in a clip and dried at 115°F stretches unduly, although a lighter sheet may be quite satisfactory. If the sheets are airdried for some days before smoking there is no stretching and this method of hanging may be very useful if the loss of a small proportion of first grade rubber is not regarded as an insuperable obstacle.

In Malaya a design of smokehouse known as the "Devon" type is used on many estates and there are a few examples in Ceylon. In this type of building the hanging racks are in the

form of trolleys which run on rails and are pulled out on to a verandah for examination of the sheets. This system enables the examination or changing of sheets to be carried out conveniently and also leads to economy of heat and smoke as passage ways are eliminated in the smokeroom. The absence of passages probably also helps to promote uniform ventilation. Obviously this type of building is expensive to construct as the verandah must be equal in size to the smoking room, and the trolleys must be substantially made if they are to give satisfactory service. Apart from initial cost this type of smokehouse can be recommended with confidence as the most efficient available and if, by ensuring that smoking is completed in 6 days, a small building can be made to serve the purpose for which a larger building was previously considered necessary, the cost need not greatly exceed that which it is at present considered reasonable to incur in building a smokehouse.

SUMMARY

The results of the investigation may be summarized by saying that a satisfactory method has been devised for the preparation of standard quality smoked sheet on estates where it is important that firewood consumption should be reduced to a minimum, and that this can be done without expensive equipment or increase in cost of production. Under certain conditions the cost of curing by this method may be less than that of normal smoking.

Attention has also been drawn to the various factors on which the efficiency of smoke curing depends and regulation of which may lead to a materially higher standard of economy.

In conclusion, the writer would like to express his thanks to the proprietors of Culloden Estate for providing rubber for the experiments at cost price and to Messrs. D. Davidson and C. Gilliat of Culloden Estate for their co-operation in the experiments.

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DISCUSSION

Following the reading of Mr. O' Brien's paper, His Excellency commented on the interesting character of the paper and expressed the thanks of the meeting to its author.

Dr. Youngman asked Mr. O'Brien if he had experimented to find out the possibilities of colouring smoked sheets as such coloured sheets seemed to have commercial possibilities.

Mr. O'Brien replied that he had some time previously carried out some experiments in which the sheets were coloured by the addition of phenolic substances to the latex. At one time it seemed that this might be a practicable proposition, although there were certain disadvantages. To begin with, coloured rubber had the properties of airdried sheet, which, he understood recently, was inferior. If that inferiority was only due to the presence of paranitrophenol there might still be some scope for preparing coloured sheets. But there was the other point that the amount of firewood required for the colouring of the sheets was so small that it did not really pay to put colouring matter into rubber, and there were few estates where firewood was so scarce that a small amount of wood could not be provided.

Mr. H. L. De Mel asked Mr. O'Brien if he had any experience of smoking sheets with the smoke of coconut husk, which contained a certain amount of creosote, which acted as a disinfectant. To his knowledge such sheets were ordinarily resistant to mould.

Mr. O'Brien : I think there is no doubt that sheets smoked with coconut husk are particularly resistant to mould, but unless the smoking is done fairly slowly you get a rather shiny sheet, which the market does not like. He added that the sheets which Mr. Barnacle had sent him as a sample were entirely smoked in this way. He believed, however, that Mr. Barnacle at first got his husk for nothing, but later when he had to pay for them he found that firewood was slightly cheaper.

Mr. H. A. Webb desired to know what the market really wanted and whether appearance, which after all was purely subsidiary, could not be dispensed with as a criterion of value.

Mr. O'Brien : That is rather a difficult question to answer, because I don't think the manufacturers themselves are agreed as to just what they want, the fact being that for different purposes different qualities are required. I should say that actually the two most important properties of rubber are : firstly, its ageing properties, namely, that it does not perish too quickly after vulcanising (and this investigation shows that smoking plays a part in improving rubber in this respect), and, secondly, its plastic property, so that it is easily broken in the mills at Home.

He explained further that it did not necessarily mean that soft sheets would be plastic. There was something to be said for selling on appearance, for it meant that the rubber was free from dirt and was manufactured carefully and, therefore, possessed normal properties.

In reply to a question by Mr. De Zoysa, Mr. O'Brien said that he personally did not favour the use of clips, although they made the rubber easier to handle in the smokehouse.

Mr. R. G. Coombe asked whether during the airdrying mentioned by Mr. O'Brien there was much humidity.

Mr. O'Brien replied that ordinary airdrying took anything from 14 days upwards. In dry weather he expected the sheets to be dry in 14 days, but he had known sheets requiring six weeks in a moist atmosphere. When he had remarked earlier that the moisture content had been reduced to 2 per cent. in four days he considered that that had come about independently of weather conditions and was more a case of the moisture wanting to get out of the sheet than being forced out.

THE CONTROL OF OIDIUM LEAF DISEASE

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INTRODUCTION

IN view of the depressed condition of the rubber plantation industry at the present time and the urgent necessity for retrenchment in every direction, I feel that an apology is due for reading a paper which is not directly concerned with economy in costs of production. Indeed it would seem that I am advocating the adoption of a measure which will add to the already overburdened expenditure of the rubber estate. An institute such as the Rubber Research Scheme, however, in addition to dealing with problems of immediate practical importance to the planter, must also look to the future and conduct researches which will be of ultimate benefit to the industry. Hence a great deal of attention has recently been devoted to the problem of controlling *Oidium* leaf disease, although it is unlikely that under present conditions many estates will adopt the method to be described, *i.e.*, dusting with sulphur powder.

STATUS AND ECONOMIC IMPORTANCE OF OIDIUM

The symptoms of *Oidium* leaf disease are now too familiar to need description in this paper, but before discussing control methods a brief survey of the status of the disease in the various rubber-producing countries may be of interest.

In Java the disease was first reported in 1918, and has increased in severity in successive years. At the present time it causes serious defoliation over thousands of acres during the weeks immediately following the "wintering" period, and has been one of the foremost subjects for investigation by Dutch scientific workers. In Malaya *Oidium* occurred for the first time in 1928. During the last two years it has spread to many districts and has now been declared a notifiable pest. The disease was first reported in Ceylon in 1925, being found simultaneously in most of the rubber-growing districts. It is now present on probably every estate in the Island, though the extent of defoliation caused by the fungus varies greatly in different localities. In the main low-country districts the fungus is active for a period of about two months from the middle of February to the middle of April, and any tree which puts on new leaves during

this period is attacked and partially defoliated. Owing to the fact that the fungus is passive during the remaining ten months of the year only a proportion of the trees is attacked to any serious extent, and these trees are able to recover by producing a secondary crown of foliage. On the other hand in certain mid-country districts, notably in parts of Matale and Uva, the virulent period is of far longer duration with the consequence that all trees are attacked and a process of continual defoliation results. In badly affected areas as large a proportion as 50% of the trees may be found to be completely defoliated.

It is indeed fortunate that *Oidium* should have attained this severity not in the main low-country rubber-growing districts, but in the mid-country where rubber-growing is relatively unimportant to the Island as a whole. It seems probable that the climatic conditions in the wet low-country districts are unfavourable to prolonged activity of the fungus so that extensive defoliation is not to be expected. The possibility, however, of the disease becoming more serious in these localities must be kept in view, and it was therefore considered very necessary that the control of *Oidium* should be investigated.

At this stage it will be well to consider the economic significance of *Oidium* in Ceylon. The importance of *Oidium*, as of any other disease of *Hevea*, must ultimately be judged by the loss in yield entailed. A costly method of disease control will not commend itself to the planter and estate proprietor unless it can be shown (1) that the disease, if allowed to remain unchecked, will eventually cause losses in yield; (2) that the control method is effective; and (3) that the comparative increase in yield of the treated rubber compensates for the expenditure involved. The first two points are dealt with in this paper. As regards the third no reliable figures are yet available, and the financial aspect of the treatment must necessarily depend, to some extent, on the selling price of the commodity.

There is at present a lack of reliable information regarding the effect of severe *Oidium* attack on yield. In Java, where the disease has caused serious defoliation for many years, considerable decreases in yield have been reported, though I have seen no scientific data on the subject. In Ceylon no decreases in yield have, so far as I know, been attributed to *Oidium*, and it is hoped that yield records which are being kept on a badly affected estate will elucidate this point. Surprise may be expressed at the ability of a severely defoliated tree to yield an apparently undiminished flow of latex, and in endeavouring to find an explanation we are unfortunately handicapped by our ignorance of the function of latex in the tree. There can be little doubt that abnormal defoliation is seriously detrimental to bark renewal, and the full effect of *Oidium* will

therefore not be apparent until the bark is being tapped that has renewed during the years in which the disease was active. On no estate in Ceylon has *Oidium* been severe for more than about four years, and during these years the bark that has been tapped was fully renewed while the foliage was healthy. Resting due to restriction has resulted on most estates in the possession of large reserves of bark so that the effect of poor renewal during the past few years has not yet been in evidence. It is anticipated that unless control measures are taken the yield of severely affected estates will soon show a decrease which will become more marked in successive years. The evils of poor bark renewal are familiar to all rubber planters, and the desirability of adopting efficient measures to control the cause thereof will therefore be appreciated.

CONTROL

In the control of a leaf disease there are always three possible lines along which research may be conducted: (1) by breeding immune or resistant varieties of the host plant; (2) indirect control by cultivation methods; (3) direct control by killing the causative fungus. I will deal briefly with the first two considerations before describing in some detail the method of sulphur dusting.

(1) *Breeding immune or resistant varieties.*—If an immune variety or species were found it could be grafted on to a high-yielding stock so that the composite tree would possess an immune crown of foliage. There is at present, however, no evidence of any inherent immunity or resistance amongst individual trees of *Hevea braziliensis*. In Java, Bobilioff has bud-grafted three different species of *Hevea*, *H. collina*, *H. guyanensis*, and *H. spruceana* high up on stocks of *H. braziliensis*, and these buddings have been planted out on two estates heavily infected with *Oidium*. Now, however, that an effective method of controlling the disease has been found it is doubtful if these composite plants will be of commercial value.

(2) *Indirect control by cultivation methods.*—It is a well-established fact that the application of nitrogenous manures benefits the foliage of rubber, and recent experiments and observations in Ceylon and Java indicate that trees manured in this way, while no less susceptible to attack by *Oidium*, are better able to recover from the effects of the disease. In severely affected areas, however, where *Oidium* causes a process of almost continual defoliation throughout the year, the adoption of manuring and other cultivation methods is of little value. Where the period of virulence is short nitrogeneous manures will assist the tree to put out a secondary crown of leaves to replace the foliage destroyed by *Oidium*, but in badly affected areas this secondary

crop will also be attacked and therefore the value of the manures lost. Heavy nitrogeneous manuring delays the wintering period and in some localities it may thus be possible to postpone the time of refoliation until the fungus is inactive.

To summarise these remarks, the application of nitrogeneous manures to severely affected areas is not recommended, although on more mildly affected estates the worst effects of the disease may be largely ameliorated.

(3) *Direct control by killing the causative fungus.*—For effective control of a fungus disease by the application of a fungicide three conditions must be satisfied. First, the fungicide used must be highly toxic to the causative organism; secondly, the technique must be such that the fungicide reaches the necessary parts of the host plant; and thirdly, the application must be made at the right time in relation to the life-history of the fungus and of the host.

In the search for an effective means of controlling *Oidium* the first of these provisions was easily satisfied, since experience with diseases caused by other powdery mildews has shown that sulphur, in one form or another, is the most effective fungicide. The problem of applying sulphur to the foliage of the rubber tree was, however, less easily solved. The first experiments were carried out in Java with Sulfinette, a lime-sulphur preparation. Spraying with this fungicide was found to give a certain measure of control but was relatively unsatisfactory owing to the high cost of the treatment. Liquid spraying of *Hevea* must necessarily be an expensive, slow and troublesome operation owing to the difficulty of projecting a fine spray to the required height. The operation is largely dependent on a ready supply of water, and on some estates the cost of transporting water would be prohibitive. The average cost of spraying rubber with Sulfinette is about Rs. 15-00 per acre, an area of about 1-1½ acres being treated in a day.

The problem, therefore, was to find a method of spraying sulphur which was effective, cheap, quick and universally applicable.

SULPHUR DUSTING

As the result of some years of experiment the Dutch workers in Java evolved the method which is now regarded as the standard treatment for controlling *Oidium*. It was clear that if finely powdered sulphur could be applied in a dry form the problem of the supply and transport of water would be eliminated. Dusting from aeroplanes was given a trial but although good results were obtained this method has, I understand, been discarded on account of the cost. The method now adopted

consists, in brief, of projecting upwards a cloud of finely divided sulphur powder by means of a small power machine which can be carried through the estate by coolies. At this stage it may be stated that the method has been used with great success over thousands of acres in Java during 1929 and 1930, but that in Ceylon it is still in the experimental stage. Owing to different conditions of environment, climate, etc., in the two countries the problems of *Oidium* control are not identical in detail, and further experiments are necessary before the same degree of control is obtained in Ceylon as in Java. Experiments which have so far been carried out have given very promising results, and have shed light on many important points.

THE DUSTING MACHINE

The machine which has been mostly used in Java and in our experiments in Ceylon is the Björklund Duster. The power is supplied by a two-stroke petrol engine which drives a fan at high speed. Sulphur is admitted to the fan chamber from a hopper with a feed regulator and is blown up through a chimney. The whole forms a compact unit mounted on an iron stretcher, and is slung from poles and thus carried on the coolies' shoulders. This machine has proved to be very efficient and economical to run. Other dusters are on the market, and an experimental machine of British manufacture has recently been tested in Ceylon.

The Sulphur.—It is essential that very finely divided sulphur be used since the success of the dusting operation is entirely dependent on the cloud-forming properties of the powder. Broadly speaking two suitable forms of sulphur are available: (1) Volcanic sulphur from Java, which needs sun-drying and sifting before use; and (2) specially prepared dusting sulphur of which American firms appear to have the monopoly. American sulphur can be used without any preliminary drying or sifting. It is more expensive, however, than the Java product, and it is doubtful if the saving in the labour of drying and sifting compensates for the higher initial cost.

THE DUSTING OPERATION

For the dusting operation ten or twelve coolies are required according to the nature of the ground. It is usually possible to treat the greater part of a field from the paths or roads, but it is occasionally necessary to negotiate rough and steep ground. Although four coolies can carry the machine on flat ground it is usually desirable to have six or eight coolies available for this purpose. The remainder are employed in carrying the sulphur and feeding it into the machine.

The engine is started, sulphur fed into the hopper, and the dusting is in progress. The machine is carried, while working,

along suitable paths or lines, the output of sulphur being regulated according to the strength and direction of the wind, the lie of the land, and the rate of progress. The sulphur is ejected in the form of a cloud of very fine particles similar in its behaviour to smoke. The distance to which the sulphur carries, and therefore the working range of the machine, is dependent on the strength of the wind. On a still day the sulphur rises very high and often forms a cloud above the tops of the rubber trees. Under such conditions the machine has a small range of action and the dusting process is comparatively slow. A strong wind is unfavourable unless blowing down a steep slope since the sulphur does not then rise sufficiently high. The ideal conditions are a slight steady breeze which permits the sulphur to rise to a sufficient height and at the same time wafts it slowly through the foliage. If such a breeze is blowing across the direction in which the machine is being carried a distance of about 100 yards can be effectively dusted from each line. The problem of applying the dust to every portion of a rubber field is not one on which any hard and fast rules can be laid down. Every area must be treated on its own merits in accordance with the local and wind conditions obtaining at the time. As the result of experiments which have recently been carried out on steep land in Uva I have come to the conclusion that it is of great importance that every little corner of a field be adequately treated. This is often a matter of extreme difficulty on steep and rocky ground, but if necessary the acreage covered in a day must be sacrificed in order to ensure that every portion receives its full quota of sulphur. As far as cost is concerned the acreage treated in a day is relatively unimportant since the cost of the operation lies almost entirely in the sulphur. Under favourable conditions on well roaded land an area of 100 to 150 acres should be covered in a day, but on steep land, such as is common in the mid-country districts of Ceylon, 50 acres is a more probable figure.

Such questions as the minimum effective quantity of sulphur per acre, the number of applications and the period elapsing between successive applications must be subjects for further investigation, and will depend largely on the severity of the disease. In Java the first application is made immediately before the outbreak of *Oidium* on the young leaves produced after "wintering." A careful watch is kept for signs of renewed activity, and as soon as the disease is seen a second application is made. This probably follows two or three weeks after the first dusting. This process is continued during the two or three months in which the fungus would naturally be virulent, a total number of five or six applications probably being made. The quantity of sulphur used is about 10 to 12 lb. per acre, though further experiments are being carried out to discover the minimum effective dose.

In Ceylon the optimum time to commence dusting provides a more difficult problem, since in badly affected areas the fungus is active throughout the year. Even in such localities, however, a period of maximum virulence covering the time of normal refoliation is evident, and dusting should probably be commenced at the first advent of young leaf after "wintering." Subsequent applications should be made at approximate fortnightly intervals until all the trees are in mature leaf. The problem is complicated by the fact that in the mid-country districts of Ceylon normal wintering is irregular and protracted so that for several months there is abundant young leaf and flower which the fungus can attack. In the experiments which have so far been carried out in Ceylon about 12 lb. of sulphur per acre per application have been applied. There is evidence, however, that in the most severely affected areas this quantity is insufficient, and it is probable that a greater quantity of the fungicide should be used at least in the first one or two applications.

RESULTS

In dealing with the most important aspect of sulphur dusting, *i.e.*, the results obtained, I will first refer to the work in Java. As regards the effect of dusting on increased rubber production very few figures are yet available. The only figures I have seen indicate an increased yield of over 50% on dusted as compared with undusted plots. I am not, however, disposed to place much reliance on these figures since the experiment has been in progress for too short a time. There seems no doubt that as regards foliage the dusting treatment has achieved phenomenal success in Java. Almost 100% control is claimed, only slight secondary attack being evident, while the abundance of flower, and subsequently seed, in dusted areas is a striking feature.

In Ceylon we cannot yet claim to have achieved so great a measure of success. Yield records are being taken from plots in neighbouring dusted and undusted fields, but these have not yet been in progress for a sufficiently long time for any conclusions to be drawn. In the absence of evidence regarding the value of sulphur dusting in respect of yield attention must be confined to its effect on the foliage.

A number of photographs have been taken illustrating the benefit to the foliage due to sulphur dusting. These are passed round for inspection, and are readily understood by reference to the explanatory footnotes.

As an additional means of judging the results of the treatment a series of light tests was taken in a dusted and a control field. The method consists of exposing a small circular area of photographic printing paper to the light for a certain specified time, the depth to which the paper is tinted being proportional to

the intensity of the light. Provided, therefore, that the intensity of the light is constant the depth of tint is inversely proportional to the amount of shade caused by the foliage. The results of the light tests taken in a number of plots in a dusted and a control field is shown in the photograph exhibited. It will be seen that the discs relating to the control rubber are darker in tint than those exposed under the dusted rubber, thus showing that the dusted foliage was denser than the control.

Other methods have been used to demonstrate the benefit due to dusting, and certain figures were given in a previous publication issued as Leaflet No. 11 of the Rubber Research Scheme (Ceylon.)

To summarise the results obtained in the experiments which have so far been conducted in Ceylon, a considerable benefit to the foliage has been secured, though the fungus has by no means been completely controlled. It was not to be expected that the first experiments on an entirely new treatment such as sulphur dusting should be completely successful. Various reasons for the failure to secure complete control have been deduced, and these points will receive special attention in future experiments.

QUANTITIES AND COSTS

The cost of the highest grade of Java volcanic sulphur is about 6½ cents per lb. f.o.r. Colombo for quantities of ten tons and over. The cost of making one application of sulphur on the basis of 12 lb. per acre and 100 acres per day works out at about Rs. 88-00 per day, or 88 cents per acre, made up as follows:

	Rs.	cts.
1200 lb. Sulphur @ -/06½ cts. per lb. ...	78	00
12 coolies for carrying duster and sulphur @ -/60 cts.	7	20
1½ gallons petrol-oil mixture ...	3	00
	88	20

This excludes depreciation on the machine and the expense of special supervision. It will be seen that the cost of the operation lies almost entirely in the sulphur, the labour and the running expenses of the machine being very small items. On severely affected estates it is probable that six applications would be necessary at a cost of about Rs. 5-00 per acre.

CONCLUSIONS

I have endeavoured in this paper to indicate first the necessity for undertaking control measures on estates severely affected with *Oidium*, and secondly a method by which control may be secured. Although sulphur dusting is still in the experimental stage in Ceylon there is no doubt that it is a quick, effective, and comparatively cheap means of control. There are

still many points which only further experiment can elucidate. For example, it is not known to what extent dusting will be a permanent cure,and whether it will be necessary to carry out the treatment every year. It seems probable that if concerted action were taken by all estates in a badly affected district the fungus would, in a few years, be to a large extent stamped out and could be kept under control at a small expense. It is hoped that interest in sulphur dusting will be stimulated by a recovery in the price of rubber.

The results of the most recent dusting operations in Java are not yet available, and it is possible that some of the statements I have made will need to be modified in the light of future experience.

ACKNOWLEDGMENT

In conclusion, I should like to express my gratitude to the Superintendents of Bandarapola, Kandanuwara and Gonakelle Estates whose assistance and co-operation in the sulphur dusting experiments has been of great value.

DISCUSSION

His Excellency the Governor said he felt sure that many members would like to ask questions or make observations on the subject.

Mr. T. H. Holland desired to know whether the leaves were wet or otherwise during the application of sulphur.

Mr. Murray said that dusting of sulphur was usually undertaken during dry weather, when the leaves were not wet except perhaps with dew in the early morning. He understood, according to work carried out in Java, that the sulphur was just as effective if dusted on wet leaves as on dry.

Mr. Robert De Zoysa said that he was interested in the economic side of the question and wished to know whether the 12 lb. of sulphur per acre was irrespective of the number of trees treated.

Mr. Murray said that it was not practicable to treat individual trees. The method employed was to throw up a cloud of dust which was carried some distance by the wind.

Asked as to the duration of the effect of sulphur, he said that this was a point on which there was still no definite data. The treatment was carried out during a period of *Oidium* attack, roughly speaking once a year, and on the young leaf immediately after wintering the dusting being repeated at fortnightly intervals. Another way of answering the question might be to state that sulphur remained active as a fungicide on the leaf for about ten days after dusting.

Mr. R. G. Coombe invited the lecturer's attention to his remark regarding conditions in the mid-country, particularly Uva, and asked whether Mr. Murray would recommend the application of sulphur on the old foliage as on trees which had just come back from wintering.

Mr. Murray said that on matured leaves the fungus was found active in what was known as "secondary attack," but it was also in a passive state throughout the year, and whether a fungus could be killed in its passive state was not yet known, but he thought that treatment would not be probably effective at all. He therefore thought that it would not be of much value to apply sulphur on trees before they had wintered. This was a point for experimentation and indeed the whole process was in an experimental stage in Ceylon at present.

Mr. Coombe then enquired as to the cost of the machinery.

Mr. Murray replied that a machine cost 825 gilders in Java, which worked out at rather over Rs. 900 in Ceylon.

Mr. Gordon Pyper desired to know whether any danger was to be anticipated of infection of the soil through falling of the leaves attacked by *Oidium*.

Mr. Murray thought not owing to the character of the fungus, but there was a possibility that fallen leaf might give rise to infection if the fungus had formed spores which were able to withstand desiccation.

In reply to Mr. Pyper's question as to whether there was a possibility of cover crops being affected, Mr. Murray said that there was no evidence at present that the fungus which attacked rubber leaves could also attack any of the cover crops. There was an *Oidium* which had been found to attack Vigna, but that he did not know whether it was the same which attacked rubber or not, for although structurally the same they might be biologically different.

Mr. Ragunathan asked whether there were figures of comparative yields of sprayed and unsprayed plots.

Mr. Murray said that an experiment to determine the point was being carried in the Matale district and yields were being recorded from dusted and undusted fields. So far there were no results but he doubted whether there could be any increase of yield in treated areas for some time yet.

Mr. R. Smerdon wished to be informed whether there was any hope of sulphur dusting being effective against *phytophthora* too.

Mr. Murray thought not, because in the first place dusting against *oidium* was undertaken at a time of the year when *phytophthora* was not active. Sulphur again was not active against *phytopthora* in the same way as against *oidium*. In further reply to Mr. Smerdon he said *oidium* would attack trees of any age.

H. E. The Governor thanked Mr. Murray for his paper and he hoped that before long the rubber industry might be in a position to take advantage of the excellent work which was being done for the industry.

ROBUSTA COFFEES AND THEIR COMMERCIAL POSSIBILITIES

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IN all agricultural countries, more particularly in the tropics, it is desirable that information should be accumulated about any crops that hold any hope of profitable cultivation in the event of a failure, or continued depression of prices, of the major agricultural products of the country.

The tragic termination of the great coffee industry of Ceylon is now a matter of history. The coffee then grown was *Coffea arabica* or Arabian coffee, which, on account of its superior quality still constitutes the bulk of the world's supply of commercial coffee. This coffee succumbed in Ceylon to a leaf disease, *Hemileia vastatrix*, aided by the attacks of a scale insect known as the green bug. With the provision of adequate shade, and with modern knowledge in the control of plant pests, it is possible that Arabian coffee could again be profitably cultivated in Ceylon. A few small plantations do in fact exist, but the leaf disease, though not necessarily severe, is always present, and large-scale planting of Arabian coffee could not be safely recommended.

There are other types of coffee, however, which are far more resistant to the leaf disease. The Robusta types have now been established in Ceylon for a considerable number of years and these coffees are practically unaffected by the leaf disease. Unfortunately, though the yield is good, the product is inferior in quality to Arabian coffee. Robusta coffees, however, have acquired a definite position in the world's markets and it is believed that these coffees can be profitably cultivated in Ceylon at the present time.

The home of the Robusta coffees is Central Africa, but they were introduced into Ceylon from Java where they have been extensively cultivated. There are a number of varieties which can be classed as belonging to the Robusta type. Six are represented at Peradeniya—Robusta, Quillou, Canephora, Uganda, and a Hybrid of Canephora of which the exact origin is not known. These varieties have been described in the Dutch East Indies, but the plots at Peradeniya do not exhibit the given characteristics of each with any degree of uniformity. Fortunately, however, here is comparatively little to choose between the varieties, either in general vigour, yielding powers, or in the quality of the product.

It is stated in Java that Canephora is more suitable for high elevations; this may be so in Ceylon but information is at present insufficient to give an opinion as to the suitability of any one variety to any particular elevation or district.

Robusta coffees are being successfully grown in Ceylon on a variety of soils at elevations from sea level to 3,500 feet, and under a rainfall of 80 to 150 inches.

The cultivation of coffee is in many respects very similar to that of tea. Berries from selected vigorous bushes should be rubbed in charcoal or ashes to remove the pulp and sown, flat side downwards, in carefully prepared nursery beds; or the seed may be first germinated in a bed of moist sand or cattle manure. Light shade should be provided in the nursery and the surface soil should be kept loose and free from weeds. The use of supply baskets adds to the expense but saves loss in transplanting. A pound of fresh berries should produce enough plants to plant up about 1½ acres 10 ft. by 10 ft. This is considered a suitable planting distance for the Robusta types on reasonably good soil and gives 435 bushes to the acre. There appears to be no general agreement as to the best age at which to transplant coffee and plants can be moved at any age up to two years.

The question of shade is of great importance and temporary shade has first to be provided. This can be most easily done by sowing, a season before the coffee is planted, rows of one of the taller leguminous bush plants alongside the coffee rows; or a ring of such plants may be sown round each hole. In default of this arrangement artificial shade of coconut leaves, bracken, wild cinnamon or any suitable material will have to be provided. Permanent shade of the right type and density is generally considered to be essential and should be established at least one or two seasons before the coffee is planted. Many trees have been used in different countries—for low and medium elevations in Ceylon *Leucaena glauca* is considered very suitable. When the coffee is about a year old the removal of suckers must be started and this operation must be repeated at intervals of not less than a month throughout the life of the coffee. When the bushes are about six feet high they should be topped to four and half feet. An alternative plan is to top earlier at two feet, then when side branches have formed below this level, allow a sucker to grow up for another four feet or so and top this back to the desired height. Those who favour this process of building up the bush in two storeys claim that it results in a better development of side branches. Pruning proper is generally not necessary before the third or fourth year.

As regards cultivation, there is a prejudice against forking coffee on account of disturbance of the shallow root system. Envelope-forking has, however, at Peradeniya, been attended by apparently beneficial results.

Most authorities favour a heavy mulch which, it is claimed, will bring about the desired soil texture as effectively as cultivation would do.

No large-scale manurial experiments on coffee have been carried out in Ceylon but experiments in Costa Rica indicated the necessity of a complete mixture to secure the highest yields. A notable point in these experiments was the adverse effect of heavy doses of nitrogen without potash, though when potash was added the same applications proved beneficial. It was also found that sulphate of ammonia was much more effective than nitrate of soda. Another point of interest was that the highest yield was obtained from the plot which analysis showed to be most acid thus indicating that coffee like tea is an acid tolerant crop.

With regard to green manuring, when coffee is full grown there is but little room for the growing of bush leguminous plants between the rows, but in young clearings such plants as the Tephrosias and Crotalarias may be advantageously sown.

Very little information is available as regards the use of a ground cover crop in coffee but in young clearings on steep land there are strong arguments in favour of the use of such a cover. A non-climber should be chosen and *Indigofera endecaphylla* can be recommended.

In Ceylon Robusta coffees usually bear a small crop in the third year while they should be in full bearing by the fifth year.

The crop season is less sharply defined than for *Arabica*. The main season at Peradeniya is between October and February but small quantities of ripe berries can be picked from one or other of the varieties in almost any month of the year.

The Hybrid appears to have no fixed season and bears regularly throughout the year.

The average yield of the different varieties of Robusta coffees at Peradeniya varies between five and seven pounds of fresh berries per bush per year. The yields are subject to remarkable seasonal fluctuations. The out-turn of parchment coffee from fresh berries is about twenty-two per cent. and it would appear that in Peradeniya conditions a yield of $4\frac{1}{2}$ to 5 cwt. per acre of parchment coffee could be expected. Larger yields than this are reported from Java.

The small grower who does not wish to invest in a pulper can produce a saleable product by merely drying the berries in the sun. Robusta coffees were sold in this form for some years at the Experiment Station, Peradeniya, and fetched between 20 and 30 cents per pound.

A higher priced product can be obtained by pounding the sun-dried coffee to remove the husk, but this is a somewhat laborious process. For larger areas it will be necessary to instal a pulper. The curing of coffee cannot be described in this short paper but details will be found in the Department of Agriculture's Bulletin No. 87 entitled "The Cultivation and Commercial Possibilities of the Robusta types of Coffee." Parchment coffee produced on the Experiment Station fetches locally from 40 to 43 cents per pound, while London valuations last year were from 80 to 85 shillings per cwt. The London brokers reported that there was very little to choose between the different varieties but that there was usually a fairly free market for such coffees, which, being of poor and rather common liquor are chiefly used as low price coffee.

In Bulletin 87 an attempt is made to estimate the probable profits that can be expected from the cultivation of Robusta coffees. The almost complete absence of reliable Ceylon figures makes this rather a difficult task. The estimate deals with the cultivation of one acre of coffee by a small-holder and the capital charges for the first two years are estimated at Rs. 234·20 exclusive of the cost of purchase or lease of land. In the third year it is estimated that the proceeds of the sale of the first small crop could cover the upkeep charges. In the fourth and subsequent years the recurrent charges are estimated at Rs. 137 per acre. The average annual crop is estimated at 688 lb. of sun-dried coffee, which at 25 cts. per pound would realise Rs. 172·19, leaving a profit of Rs. 35·19 per acre.

It is believed that in actual practice a small-holder would seldom incur the capital expenditure estimated while the crop estimate is conservative. Figures obtained from villagers by the Agricultural Instructor at Kegalle show a profit of Rs. 202·50 per acre, but the recurrent annual charges are put at only Rs. 15·00 per acre and it is thought hardly possible to carry on the cultivation at such a low figure. An estate in the Namunukula district gives the profit from 15 acres of Robusta coffee at Rs. 101·00 per acre. These are widely-divergent figures but there seems little doubt that the Robusta coffee can be profitably cultivated over a considerable area in Ceylon.

The steady demand for seed and plants shows that this is already realised by a fairly large section of the agricultural public, but it is thought that there is room for a considerable extension of the planting of this useful crop.

DISCUSSION

His Excellency said that the subject, a matter of interest at all times, was never perhaps of more interest than at present when they were endeavouring to discover profitable side lines which might help them when their major crops were in a state of depression. It would appear that at the moment all crops were in a state of depression and even coffee would not help them very

much. He, however, thought that it was unusual that economic conditions in the world should be what they were at present and depression should be so widespread and universal, and it was conceivable that at other times when one industry was depressed some other subsidiary industry should come to its rescue, and they should therefore not overlook the possibility of cultivating subsidiary crops in times of difficulty.

Mr. J. B. Coles enquired whether Mr. Holland could say if Robusta was attacked by scale insect, to which he thought the failure of the industry was due in the past rather than to leaf disease.

Mr. Holland replied that he had mentioned that Robusta was subject to attack from this pest, also from leaf disease, but he had never seen any very serious infestation and the scales were nearly always parasitised.

Mr. H. L. De Mel remarked that when Mr. Holland was away on leave he had brought up the question as to whether they should not revive coffee in the Island. He did so because he had experience in the product himself, having obtained some seed in 1917, out of which he had some splendid seed-bearers and now had 10 to 12 acres under coffee in the Kurunegala district. When he brought up the question of a revival Dr. Small expressed the opinion that it would be necessary to grow Robusta at an elevation of at least 2,500 feet. This however, was not his experience, for he found in the last 10 or 12 years that it could be grown at an elevation of even 500 feet. The difficulty was rainfall for when it was below 80 inches the berries were very small. In the last 7 or 8 years his yields were between 300 and 350 lb. per acre, and he found no difficulty in selling all of this at the nearest Sunday Fair organised by himself. Mr. De Mel explained that his object was purely to give local inhabitants the privilege of buying home-grown coffee rather than put it on the Colombo market. The selling price was between 30 and 40 cents per lb. of pounded coffee, the parchment he reserved for his own use and that of his friends.

From his experience he thought that those who had land of fairly good soil available could grow coffee profitably planted at 12 by 15 feet with *Gliricidia* for shade. Recently he had inter-cropped coffee with plantains and they were both doing very well. Cattle manure gave wonderful results. In the early days he knew very little about topping and had let the trees grow very tall, but a visitor from Java gave him the same advice as Mr. Holland and asked him to do topping in two storeys. There was no *Hemileia vastatrix* at all, and the scale was being controlled by parasites.

His Excellency asked whether experiments had been made in growing Robusta in altitudes higher than those mentioned by Mr. Holland. In Africa he had seen Robusta grown considerably higher than that and with considerably lower rainfall than 100 inches.

Mr. Holland said that on the information he had the highest at which Robusta was grown was at Kandahena Estate, Namunukula, about 4,000 feet.

His Excellency: I have seen it grown at 5,000 feet.

Mr. Holland: That will be Arabian coffee.

His Excellency: No, Robusta.

In reply to Mr. G. Robert de Zoysa, Mr. Holland said he did not think the coconut tree was the ideal shade for coffee. Further, the roots were very extensive and would act detrimentally on the coffee.

Dr. Youngman: Could Mr. Holland give us the advantages and disadvantages of high and low shade ? He added that in Central India coffee was grown at 4,000 feet under grevillea shade.

Mr. Holland replied that as far as Ceylon was concerned there was no definite information on the point, but in South India grevillea was considered suitable shade for coffee. He could not see the reason for it as the shape of the tree was not suited to the purpose, but he believed they were planted in belts and the direction of the sun was taken into consideration when they were planted. He thought that albizzia had been used in Ceylon for shading coffee.

Mr. Coles : I have seen coffee yielding very well in the Nilgiris under albizzia.

Mr. E. A. Pieris enquired whether coffee could not be grown in conjunction with hill paddy with drumsticks for shade.

Mr. Holland thought that Mr. De Mel's system of interplanting with plantains was more practicable and profitable. Drumsticks might be used as shade, but it would be better to have the coffee and the hill paddy on separate allotments.

Mr. W. I. Pieris asked whether Mr. Holland had exploited budding as distinct from grafting.

Mr. Holland replied that at present neither method had been employed but that Dutch workers had found grafting more suitable.

His Excellency warmly thanked Mr. Holland for his paper.

SOME PROBLEMS OF COCONUT RESEARCH

SIR H. MARCUS FERNANDO, KT., M.D., B.SC.

AFTER many years of weary waiting the Government of Ceylon placed on the Statute Book last year, an ordinance which enables research in this important industry of the Island to be conducted on lines parallel with research in tea and rubber. Some delay has occurred in starting this work, delay which is inevitable in undertakings of this nature, but a beginning will now be made as the Director and one or two of his assistants have already been selected. In these circumstances I have been invited to read a paper on coconut cultivation in this country with special reference to those problems which require speedy solution through applied research. The industry is passing through a time of depression, unparalled in its intensity, during the whole of the period in which it has established itself as a staple product of this country. The question then arising in the minds of all those concerned is, how research can help to tide over the present crisis. I do not mean to imply that the work of the Institute is to be confined to this, but this aspect of the question cannot be overlooked. In this paper I propose to concentrate on the problems that seem to me to require solution as soon as practicable, and which have engaged my personal attention and inquiry for a good many years.

The problems connected with coconut cultivation are so varied that they may be classified under several general heads, such as:

(a) The Physiology and Biochemistry of the palm.
(b) The Chemistry of copra, oil, and products derived therefrom.
(c) Soils and Manuring.
(d) Insect Pests.

There is a problem connected with the physiology of the plant which recently came into great prominence and seems to me one that requires the earnest attention of research workers. As a remedy for the depressed profits from coconut cultivation an editorial pronouncement in *The Tropical Agriculture* has been made, that the poor yielding palms on an estate should be removed and the vacancies thus created should be supplied by young palms grown from selected seed nuts from heavy-bearing trees. The underlying idea for this procedure is that nuts from good mother trees are likely to breed true. Now this conclusion is not only not supported by what we know of the physiology of fertilization in the coco-palms, but, I may add, that it is not corroborated by the results of experience in planting selected seed nuts.

The inflorescence of the coco-palm is of the peculiar type by which self-pollination is prevented. Let me quote from Sampson's work:

"When an inflorescence has burst out from the spathe, the flowers do not all open at the same time. Flowering commences with the male flowers at the apex of the terminal branches of the inflorescence and gradually extends to those lower down, though always commencing at the apex of these. It takes some twelve to fifteen days for all the male flowers on an inflorescence to finish flowering, and as these fade they drop off. It is only after the male flowers have finished flowering and dropped that the female flowers commence to open. In this case also the flowering commences with those flowers on the terminal branches and gradually extends to those on the lower branches. It takes from twelve to fifteen days for all the female flowers on a normal inflorescence to finish flowering and it very rarely happens that the next inflorescence bursts from the spathe till the flowering on the previous one is over. Thus there is very little chance that the pollen from the male flowers of an inflorescence will fertilize the female flowers of the same inflorescence, and there is also very little chance that the pollen from the male flowers of the following inflorescence will fertilize the female flowers of the previous inflorescence on the same tree. From this it is clear that the fruit of the coconut is usually cross-fertilized, and this explains why it is that there is so much variation in the seedlings grown from nuts harvested from the same tree and even from the same bunch. The male parent of the seed nut and the male parent of the tree from which the seed nut has been gathered are unknown. This explains why there are so many so-called varieties of the coconut and why it is impossible to differentiate between them."

So much for the results of physiological research. Now I will proceed to place before you my experience from practice. In 1894-95 I planted over one hundred acres of coconuts in the Weuda Hatpattu, at first with palms from selected seed nuts from the Colombo and the Negombo districts and later from seed nuts from a neighbouring garden. In the results as seen today no distinction appears either in yield or type of plant between the different groups planted from these different seed nuts.

Again in 1897 to 1902 over five hundred acres of coconuts were planted in the Katugampola Hat Pattu about 10 miles from Madampe. The whole of this area was planted with seed nuts obtained from very carefully selected mother trees from an estate under my control at Mahawewa. Those of you who know the sandy loam soils of Marawila and Madampe, will appreciate the fact that the palms there are of a peculiar type physically. They show little vegetative growth when once they begin to bear, and they have drooping leaves and moderate-sized stems. Whereas

Katugampola palms show bigger stems, leaves are more horizontally placed, and their vegetative upgrowth is much more marked. Katugampola palms, say twenty years old, will show higher and bigger stems than Marawila trees twice that age. Now the peculiar result of the experiment is, that there is not a single palm area in the Katugampola Estate showing the characteristics of their parents. They have accommodated themselves to the environment but show no results of heredity.

If then seed selection is to be given experimental trial it can only be conducted under the ægis of a research station. The inflorescence of selected mother trees should be protected against cross fertilization by artificial means, or they may be fertilized from other selected mother trees. Such a research obviously cannot yield reliable results for many years, but nevertheless it is one that should be undertaken. There are still other methods available for the geneticist than the one referred to, but even here it is a matter of time, and prolonged experimentation will be needed to unravel such problems.

In the department of biochemistry I should like to place before you some observations on the food value of the products of the coconut palm. These represent some estimates I made at a public lecture some years ago in dealing with the diets of Tamil estate labourers, as compared with the diet of the low-country Sinhalese and the standard diet of our jails and hospitals. The dietetic value of the coconut kernel is not generally included in the text-books dealing with coconut cultivation. Nor is this omission a matter of surprise. It is only since the beginning of this century that the physiology of animal nutrition began to develop in a new orientation. Up to that period the foodstuffs of man and animal were classified under three categories, such as proteids, carbohydrates and hydrocarbons or fats, and their relative value was determined according to the amount of heat units or calories that they were found to yield. Weight for weight the fats are capable of yielding $2\frac{1}{4}$ times as much heat energy as either proteids or carbohydrates; but proteids are indispensable for the building of tissues and for the growth and maintenance of the animal body, working on this crude basis of nutritive value one pound of rice yields 1,590 heat units, whereas one pound of dry copra or desiccated nut will yield 2,980 heat units. But the problem is a more complex one. Thanks to the investigations of many distinguished biochemists since the beginning of this century, it has been clearly proved that life cannot be maintained on a suitable mixture of the different classes of foodstuffs with mineral salts, unless certain hitherto unknown substances are also present in the diet. These substances are known as accessory food factors or vitamins. Several such factors have been described and more are forthcoming yearly. I do not

propose to refer to the vitamins in a detailed form here as such a course will lead me very far from my subject.

Moreover recent investigations have indicated to us the necessity of maintaining the proper proportions of the different forms of foodstuffs in a physiologically balanced diet. The coconut kernel from a nutritive standpoint is exceptionally rich in fats. The mature fruit contains over sixty per cent. of fats and the rest consists of proteids and carbohydrates. Rice is woefully deficient in fats. Its fat content is less than one per cent. and this deficiency is a serious cause of ill-health and inefficiency in a rice-eating people when not supplemented by a reasonable proportion of animal or vegetable fats. In the fresh kernel of the coconut we have a form of fat and nitrogenous food most appropriate to supply the deficiency of a rice diet. The low country Sinhalese consume coconuts very largely and are thus enabled to maintain their health and efficiency. The consumption of nuts is so large amongst them that the ordinary jail diet contains half a nut a day. On the other hand Tamil labourers on up-country estates away from the coconut belt consume very little coconuts with the result that they suffer seriously from those forms of ill-health now recognized to be due to fat shortage in the diet. Both laboratory experiments, and the experience of fat shortage in Germany and Austria during and after the war, go far to prove that fat deficiency is responsible for a lower resistance to microbic infections, such as pneumonia, influenza, tuberculosis, dysentery, etc., and certain forms of anæmia and debility. The Food Research Committee of the Royal Society in their 1919 report make the definite pronouncement that for prolonged and efficient muscular work at least one-fourth of the heat units in a diet should be derived from fats. The high mortality from pneumonia and influenza even in the healthy districts of the Ceylon uplands; the excessive infant mortality due to the lowered vitality of pregnant women, and their deficient lactation after child birth, all tend to show that this dietetic defect is the prime cause of these evils.

The nutritive value of the kernels at various stages of maturity of nuts has not yet been definitely established by experiment and analysis. Here, to my mind, there exists a wide field for research. We have all along concentrated on copra and oil as the end products of palm cultivation. When these are a drag in the market it may be possible to utilize young nuts as feeding material for farm animals. The mature nut is too rich in fats and proteins for a well-balanced diet for growing animals, whereas at an earlier stage they may form a more suitable foodstuff.

Before I leave this section of my subject I may refer briefly to the valuable bye-products of coconut palms in the form of palm sugar or jaggery, fermented toddy, and arrack. There is an

extensive field for research here. The present methods of production are exceedingly crude. In fresh fermented toddy, I may add, we have a form of food exceedingly rich in accessory food factors or vitamins. It contains yeast in a very active growing condition and is therefore exceedingly rich in many vitamins. Two cents worth of fresh toddy is worth a great deal more than the costly patent preparations of yeast so highly advertised in the press at present.

The chemistry of copra and products derived therefrom have been the subject of both long range as well as applied research by technical chemists who work in universities and in the big manufacturing works for many years. The progress made in the domain of the chemistry of fats and oils during the last thirty years has been phenomenal. It is the most potent cause in the depression of the copra and oil trade at the present time. Manufacturers have discovered many substitutes for the few edible fats used in commerce thirty years ago. The alteration of the physical constitution of one form of fat to another and the refinement of fats for edible purposes are now a simple process. As far as the producer is concerned there still remains many details which are still obscure. In the preparation of copra and oil the methods pursued are still empirical. There are many points where more definite knowledge of the chemistry of the products may help the producer. In the Malayan Coconut Research programme 28 items are mentioned as arranged for investigation on the manufacture of copra alone. Most of them affect estate practice. Some of the results already achieved by analytical methods go far to antagonise the views commonly held by the producer as well as the buyer for export. For instance it has been shown in Malaya that badly dried native copra may contain a high oil content; two per cent. higher than the average for good quality estate copra. These are matters which need investigation in Ceylon for our products as well. Again the effect of humidity and rainfall of a district on the drying of copra has not been sufficiently appreciated nor investigated in this country. The effect of sulphur fumes in drying, or the application of hypochlorite, etc., before drying require trial. The use of these chemicals may enable estates in damp climates to prepare copra free from mould and from deterioration in transit.

In dealing with soils and manuring many investigations have been made; nevertheless the results so far achieved are somewhat conflicting and not conclusive for sure guidance in estate practice. Those of us who have gone to great expense in the use of artificial manures, do so by sheer empirical methods. In most instances success is achieved but in what respects we are throwing away money unnecessarily are points which require immediate determination.

The conservation of humus and soil moistures are found by experience to be matters of paramount importance in coconut cultivation. How far such factors may be antagonised, or improved by tillage of the soil, are still uncertain. Scientific experiments continued for a number of years under similar conditions carefully laid down and in several districts are necessary for the guidance of estate work.

There has been a great awakening with respect to green manuring during the last ten years owing to the fact that with tea and rubber growing, clean weeding was the rule. The attempt to prevent soil erosion under such conditions brought the factor of green manuring to the forefront. Mr. Joachim, in his lengthy and interesting report on green manuring in coconut cultivation, is not quite correct when he states that coconut planters were even more behind hand in adopting green manuring as a routine of their practice, because, I will show later that green manuring in a modified form has been the practice in most coconut estates for generations. The recent wave of utilizing green manures has consisted chiefly of growing types of leguminous plants introduced from Java and elsewhere, and not so much in the utilization of indigenous species such as Crotalaria, Sunn-Hemp, etc.

In dealing with the question so fully dealt with from one point of view by Mr. Joachim, I think it the duty of those who have had experience in green manuring for some considerable time to place the results of their experience for discussion and comment. I have attempted to apply green manuring in several forms and under different conditions for good many years and shall state the results as briefly as possible.

About thirty years ago, I noticed that *Crotalaria incana* was growing very vigorously near Maligawatte Estate in Mahawewa. I had the seeds broadcasted over the estate and it was an unqualified success. The object was to obtain as much nitrogen out of the green manure as possible and this was easily attained. The analysis of the dried cuttings gave a nitrogen content of $3\frac{1}{2}$ per cent. and on that basis about 50 lb. of green stuff equalled 8 lb. of castor cake. With this vigorous growth of crotalaria, we were able to apply 50 lb. of green manure once every two years to each tree with phosphates and potash; and moreover we plough in the green stuff, including grass, etc., once every year. The results have been excellent. The yields have been greater than when we depended on organic nitrogenous manure with a great saving in cost. This system has been carried out all along and is still in force. The Crotalaria regenerates itself after ploughing and has remained free from pests for over thirty years.

When Crotalaria was introduced into other districts where gravelly and sandy soils prevail it was a failure. The growth

was slow and the plants died during the drought. There is one drawback. When Crotalaria is broadcasted and grows successfully, the pasturage for cattle is reduced considerably. On estates under my care in the Kurunegala and Negombo districts the problem was a difficult one. Here my object was to obtain as much pasturage as possible and to combine coconut growing with animal husbandry. The usual practice in coconut estates is to allow pasturage to grow between the palms and even a cursory examination will show that the pasturage is not entirely grass, but contains the valuable nitrogen fixture Desmodium. So that green manuring was always practised in coconut plantations, and the idea of introducing green manuring to a coconut estate is like carrying coals to Newcastle. The grass and Desmodium can be ploughed in from time to time and even buried round the trees, but you will agree with me that it would be a foolish practice when such an excellent fodder is available why it should not be sent through the bodies of cattle. It is a well-known fact that 50 per cent. of nitrogen in the food of stall-fed cattle can be recovered from the farmyard manure, and that a greater proportion, about 75 per cent. of the nitrogen, will go into the soil when the animals graze and are tethered to the tree in a coconut plantation.

The problem then is how to utilize this pasturage to its fullest extent. The process is a simple one. By applying phosphates and lime broadcast between the palms and ploughing in the pasturage, say once in two years, the humus content of the soil is increased amazingly and the pasturage increases in quantity as well as in quality. The Desmodium appears in greater abundance owing to the lime and phosphates, and the mineral contents of the fodder improves in those very elements they are found to be so lacking in Ceylon.

Last year I sent two samples of the pasturage from two different estates, where this practice had been conducted for several years, to Peradeniya for analysis. Mr. Joachim was good enough to analyse and send me the results. The report showed that this pasturage, which was equal to the best type of pasturage in England, contained when dried, over 3 per cent. nitrogen. In fact as much nitrogen as can be obtained from a nitrogen fixing green manure such as is generally used in the present day estate practice. But now let me work out the amount of this pasturage yielded by an acre per annum. In this matter I can only place before you an estimate quite empirically obtained, although I have worked at this subject for many years. I am able to maintain high-class bulls and cows and Jafferbady buffaloes on this pasturage alone, at the rate of one head of cattle for every two acres. From stall-fed cattle of the same type, I find that each adult cow or bull requires on an average of at least $\frac{3}{4}$ cwt. of

green pasturage daily. From these data it can be shown that at least about 7 tons of pasturage are produced per acre per annum under closely grazed conditions. This result is by no means extravagant. It looks like an underestimate. But the results from a manurial point of view are startling. Even taking the low limit of only half of the nitrogen in the pasturage is returned to the soil when passed through the body of animals we get in 7 tons of pasturage an enormous quantity of very assimilable organic nitrogen. It is equal to 11 cwt. of castor cake or 212 cwt. of sulphate of ammonia per acre per annum. You will agree with me that if these figures are reliable we have in the practice I have described a process of manufacturing a quantity of cattle manure which can more than suffice the nitrogen requirements of the palms and considerably more than the amounts used in estate practice. The cash equivalent saved amounts to about Rs. 18·75 per acre when compared with the cost of sulphate of ammonia which to-day is the economical nitrogenous manure in the market.

During the last few years a considerable amount of attention has been paid to the manufacture of what is known as artificial farmyard manure. This is intended to replace the natural production in consequence of the greater use of tractors and machinery in farms in place of animal power. As you may be aware the Rothampstead Experiment Station has obtained interesting results with straw and other similar products. Amongst other vegetable refuse experimented upon pounded coconut husks have been utilized with success.

On the suggestion of Mr. Joachim I carried out two experiments, one with coir dust and the other with decayed husks. The process is a simple one, but the experiments showed that the complete decomposition of husks require at least six months. It is not convenient to arrange for such a process to take place in pits on an estate and then transfer the finished product to the palms but a modification of the process to suit estate practice can easily be arranged. Instead of waiting for decomposition in a separate pit, we can apply the decomposed husks or the coir dust to a trench round the palms with green leaves, and the other ingredients of the mixture in the ordinary course of manuring. The changes will take place in the trench quite as freely as in the pit. This is a method of utilizing husks with green leaves which I commend to the attention of coconut growers.

As regards insect and other pests that affect palm cultivation, investigations have been made for several years by the staff at Peradeniya. Moreover plant pest inspectors under an expert have been at work for many years in all the Divisions of the Agricultural Department. The control of these pests is fairly

satisfactory. Considering how long the coconut industry has been established in Ceylon, it is a matter of satisfaction to note that damage from insects and other pests is comparatively small and is capable of control.

I have intentionally reduced my remarks to a few matters only as I believe that there are many planters of experience present who are prepared to contribute to the discussion. I hope they will be able to extend the scope of my survey and dwell on other points germane to the subject.

In conclusion, I will take advantage of this opportunity to further emphasize the important thesis I have put forth in my paper with reference to the green manuring of coconut palms. The scheme I have endeavoured to recommend is one by which in these days of depression the cultivation of the estate may be maintained at a high level and the palms kept in good heart by the smallest outlay in manuring that is possible, an outlay that may mean not more than ten rupees per year per acre; but in addition to this reduction in estate maintenance there is the subsidiary income to be obtained by the profits from cattle breeding. This is an ancillary industry which if conducted with skill and understanding can bring an added profit. I have only alluded to the breeding of cattle as a valuable help to coconut cultivation, but the method I have described need not be restricted to cattle breeding alone.

If co-operative creameries and marketing depôts are established in centres of the coconut belt, dairy farming offer an alluring prospect of affording assistance to the main industry. The rearing of goats and sheep and even of pig breeding promise similar results. The last item is one which is specially recommended in Copeland's text-book. He states: "There are also in the tropics extensive industries in pigs and in goats . . . . There is no apparent reason why the tropics should not develop a business in pork, lard, etc., the importance of which will be in some proportion to the ease with which the feed of the hogs can be raised. I am satisfied that it is possible to raise hogs more cheaply in the tropics than in any temperate country and therefore expect to see the day when such products as pork as articles of commerce shall reverse their present direction of movement." It is our common experience that even in the low-country of Ceylon excellent pigs of the best British breeds can be bred to perfection. At the present day, thanks to improvements in the science and art of refrigeration, not only the products mentioned by Copeland but even ham and bacon can be produced without difficulty in the tropics, so that what Copeland predicts for the Philippines, may become a practical proposition in Ceylon, is well within the bounds of probability.

DISCUSSION

His Excellency the Governor said they were all very grateful to Sir Marcus Fernando for his particularly interesting paper which, he was sure, would stimulate a useful discussion.

Mr. S. Kandiah, Acting Chemist, thought that one objection to Desmodium as a cover crop was that it completely covered the ground and choked æration of the soil. As regards the use of coconut husk as manure, the experiments carried out locally showed that some lignin dissolving agent had to be added to it in order to bring about decomposition.

Mr. Holland thought that *Crotalaria anagyroides* was more suitable than *C. incana,* because it produced double the amount of green manure. As regards what Mr. Kandiah had said, he thought that what Sir Marcus had in mind was *Desmodium triflorum,* which could not be said to form a close cover at all.

Mr. C. N. E. J. De Mel asked whether the statement of Sir Marcus, that green manures had been grown in coconut for several years was quite accurate. They knew that Desmodiums were found in coconut land, but this was more unintentional than otherwise, and whether green manure was cultivated before the last ten years he was not sure. He himself had introduced *Boga medeloa* into the North-Western Province four years ago.

Mr. C. A. M. De Silva agreed with the last speaker and desired to know what the experience was with Boga on his plantations in the Chilaw district.

Mr. H. A. Peiris remarked that as regards pollination, investigations in Malaya recently showed that what usually happened was self-pollination and not cross-pollination. In experiments he had conducted himself at Trinidad he had confirmed this, and he thought it might be useful to carry out tests in Ceylon too.

Dr. Diamond: With regard to the last speaker's remarks, there are types of coconut which do breed true, *i.e.,* they are self-pollinated. But the common type of coconut in copra production is, as Sir Marcus said, a hybrid, and cross-pollinated.

Mr. Malcolm Park supported the lecturer's remarks regarding mycology and diseases of coconuts. It was their experience that well-cared-for coconut estates and those run on modern methods of cultivation had very little disease. Bud-rot was prevalent in certain damp situations and then there was a serious disease known as tapering which he thought, was associated with hereditary characters. Certain palms were subject to an economic limit of age, with the result that after 20 or 30 years they declined and developed tapering. This was not a disease he thought, and probably it would be discovered, when the genetics of coconut cultivation were gone into, that this was one of the symptoms of certain types of coconut.

Mr. C. N. E. J. De Mel enumerated the various pests of the coconut and his remaks were supplemented by Dr. Hutson.

Mr. Lord said he gathered from the paper that the pasturing of cattle on coconut estates on grass actually added to the amount of nitrogen, but he thought that if the cattle were pastured on grass there could be no addition of nitrogen, becouse the grass itself took the nitrogen from the soil and it went back to the soil through the body of the animal. On the other hand if green manures were grown instead of grass these would definitely enrich the soil through their capacity for fixing atmospheric nitrogen.

Mr. C. Ragunathan thought that although green manures might have been used in the past in coconuts, the cultivators did not know the correct methods of their use.

Mr. Pararajasingham joined issue with the lecturer as to the value of ploughing, since the coconut tree was a surface feeder and the disturbance of the roots from time to time was not beneficial. The burying of husks it was thought in certain parts would encourage the breeding of the coconut beetle, but he got over the difficulty by the addition of calcium cynamide.

Mr. G. Panditasekere raised the question of the possibility of vermin and rodents infesting coconut land if there was an intensive cultivation of green manures.

Dr. R. V. Norris said that as regards the question of cultivation he had some experience in association with Mr. Sampson on the west coast of India and Malabar, where they had very light and sandy areas. There was no question of cultivation and till ten years ago no green manures were grown, the land being left undisturbed in grass or remaining uncultivated. Mr. Sampson then strongly advocated a light cultivation which just disturbed the soil a few inches, which conserved the moisture, and on these soils the effect was marvellous. A striking example was offered in the hot weather of the effect of this cultivation when areas that were not cultivated suffered visibly from the drought, whereas those that had been looked, were particularly healthy.

Mr. C. N. E. J. De Mel asked whether it was not the fact that green manures competed with the roots of the coconut on sandy soils, so that at a time of drought there was insufficient moisture in the soil for the palm

Mr. C. A. M. De Silva supported the suggestion made by the last speaker.

Dr. Youngman said that in regard to the last statement, he would like to mention what he had heard from a chemist from Java. There the experience was similar in regard to oil palms and they were now experimenting with treating their green manures with a chemical during a certain period of the year and this killed off the top growth of the green manure without however killing the roots of the plant, the whole effect in those arid regions where the oil palm grew being to conserve the moisture.

After further discussion, Sir Marcus Fernando, in his reply, desired to correct some serious misunderstandings. The advantage of *Crotalaria incana* was, though it was ploughed in once a year, it re-established itself. He was quite satisfied with it and was not going to experiment with any other. Boga could not be ploughed in, did not regenerate itself and was subject to disease. When he spoke of pasturage he meant not only grass but grass with Desmodium. A member of the audience had suggested that he was overdoing manuring. He, on the other hand, knew of an estate that had kept up a very high state of manure application and this was giving the highest yield he knew of in Ceylon, while the trees did not show that they were suffering. That yield was one ton of copra per acre per annum. The question of pollination was not one that he had had an opportunity of studying. He had simply quoted from Sampson's work who was the authority that everybody looked up to and who at the moment was expert adviser to the Kew Gardens. Sampson's observations had been made from very carefully made experiments. He agreed that there was certain types of coconut plants which were self-fertilised and of these the Maldive coconut was one.

In conclusion, Sir Marcus Fernando repeated his advice regarding the importance of an ancillary industry during a time of depression.

REPLANTING AND REJUVENATION OF OLD RUBBER*

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UNTIL very recently a crop of 500 lb. of rubber per acre was looked on as very satisfactory even in the best rubber districts of Ceylon where probably the highest average yields obtained in the East are still registered. The fact that even the first fruits of experiments in the raising of high-yielding strains have shown that this yield can with practical certainty be doubled if not trebled clearly proves that the rubber plantation industry was started in a hurry with no thought to the quality of the material employed. Seeds were bought by the thousand because they were Para rubber seeds and the result is that we have large areas of mediocre trees. There is little to wonder at when we see signs of uneasiness among owners and hear questions raised about the possibility of replacing their poor trees with more productive varieties.

With the present depression in the industry efforts have had to be made to reduce the costs of production to a minimum and in many cases estates are still working at a considerable loss. Whether the present prices for rubber are likely to improve to any very great extent I am unable to say but it is unlikely that they will ever reach the phenomenal heights that they have attained on occasions in the past. The only way in which costs of production can, in most cases, be reduced still further is by obtaining an enhanced yield. This is practically impossible, economically, on older estates which are yielding 300 to 400 lb. per acre and it is not difficult to forecast that such properties will be unable to keep their heads above water when the area under budded and selected rubber is increased so that it amounts to a significant proportion of the world's total.

It would appear that the higher-yielding estates, by dint of extra manuring and special effort to increase their yields to a maximum, will be able to carry on at a profit for some considerable time but that neglect of agricultural works in time of depression may put them in much the same category as the poorer estates. The latter in my opinion will be forced to replant or abandon, if not now, at least within measurable time.

* Read by T. E. H. O'Brien, M.Sc., A.I.C., Chemist, Rubber Research Scheme (Ceylon).

Such properties would, I think, be well advised to experiment with replanting. There is no need to undertake extensive schemes at the outset, as in all probability still better planting material than at present available will be on the market shortly, but it seems wise to make a start now before reserve funds are still further depleted by trying to bolster up out-of-date properties.

In view of the present excess of supply over demand the question as to what is to be done with this extra rubber is only natural. I am not competent to deal with this but it would appear that many new outlets would be exploited if producers could supply rubber profitably at a low figure. Roadmaking is a case in point. I feel sure that the difficulties attending the laying of rubber roadways would soon be surmounted if rubber could be obtained for a number of years at a price at which it could compete with other materials. This argument merely supports the statement that many estates will have to increase their production or close down. Dividends will be the perquisite of properties which can reduce their costs of production so that they can sell at a profit at prices approaching the present selling price of the commodity.

THE TERMS "REJUVENATION" AND "REPLANTING"

Attempts to improve the productivity of old rubber areas may be made in two ways. Either the land may be completely cleared and replanted, or a percentage of the best trees may be left and the vacancies created by the removal of the poor trees supplied with young high-yielding stock. The former is generally termed replanting and the latter rejuvenation.

REJUVENATION

Rejuvenation it is thought will be applicable only in special cases. The retention of even a small percentage of the best trees introduces an element of competition for light and ground space and the young supplies consequently suffer. As however the system is attractive in respect of the fact that the land is never completely out of production, a few comments may not be amiss.

Young rubber raised from proved budded stock has yielded as much as 10 lb. a tree in its first year of tapping and there is no reason to suspect that this yield will not be augmented as years go on and the trees increase in size. For this reason it will be uneconomical to leave permanently any tree yielding less than this amount. This is the lowest limit which should be considered and it will be preferable to leave no tree which does not reach "mother tree standard" that is, which does not yield at least five times the average yield of the trees in the field.

Considerations of shading must also be taken into account and not more than 10% of the previous stand should be allowed to remain. It is thought that if this maximum is exceeded disappointment will result. A greater stand will interfere with planting operations, with subsequent cultivation in the early years, and with the growth of the young plants.

It may be possible or desirable in some cases temporarily to leave the best 25% of the old trees to help to cover the costs of replanting. Such a stand can be expected to give 50 to 60% of the previous yield at a cheaper rate of tapping, but it is estimated that two years will be the maximum length of time that this will prove satisfactory. The danger of damage to the young plants during the subsequent felling increases greatly after this. In such a scheme I consider it advisable to plant up the full stand of young rubber as far as possible at the beginning so as to avoid the necessity of extensive supplying when the old trees are removed.

REPLANTING

The concluding part of the last section really belongs to this as none of the original trees are eventually left. Wherever possible a clean sweep at once or at a very early date is considered preferable. The young areas are given every chance to put on uniform growth. An uninterrupted contour system can be laid down and generally the work is simplified. The retention of known mother trees is naturally desirable no matter whether a clean sweep is being made or not. These are usually so few in number that they will interfere with none of the operations.

OVERTAPPING PRIOR TO REMOVAL

The desirability of realising as much as possible of the capital invested in the old trees need not be stressed. Some form of heavy tapping should be employed but reliable data on suitable methods are scanty. One thing which recent experiment has shown, however, is that, if it is desired to keep up such tapping for a year, or two, the system must not be too drastic. Tapping to the wood is undesirable except probably during the three months immediately preceding removal.

The following scheme has been tentatively suggested in an article in the April number of *The Tropical Agriculturist*, 1930:

Open the normal cut on each side of the tree and tap both on alternate days to the normal depth and with normal standard of tapping. Such tapping should avoid the bottom 9 inches or foot of the panel so that this may be available for use the year before removal. Tapping of this description can probably be kept up several years if bark is available.

The year before removal both cuts should be put down to the base of the tree so that the lower end in each case is about 9 inches above ground level. Tapping here is continued in the same way except that during the final three months tapping may be carried out to the wood and subsidiary cuts put in wherever bark exists which can be profitably exploited.

It is thought that the yield from the earlier year or years of heavy tapping may raise the normal production by 50% and the final year by 100 to 150%. These figures are merely estimates in the *real* sense of the word.

Where rejuvenation is favoured the trees to be retained will naturally be tapped in the normal way, one half cut on alternate days, and in the early stages the same will hold good where a larger percentage is being left as a temporary means of revenue. Overtapping of these latter will later follow the same lines as suggested for the generality.

Tables have been prepared showing estimates of expectation of crop during the period of replanting, including heavy tapping, and the earlier years of production of the young budgrafts. These can be inspected.

TAPPERS' TASKS DURING OVERTAPPING

The size of tappers' tasks will have to be reduced during overtapping and, to what extent, will have to be decided by trial and by a study of the economics of the situation. There are two factors here which are antagonistic: (a) if small tasks are given, say 110 trees, costs of tapping will probably be much as before; (b) with larger tasks, say 150 trees or more, the costs of tapping can be made lower but the yield will be less owing to the later tapping of a large number of the trees. In the present state of the market it is possible that smaller yields at a lower cost will be more profitable.

REMOVAL OF TREES

There is no reason why, during the period of heavy tapping, any completely useless trees should not be removed. If required for firewood the timber can be kept fresh by cutting the roots on one side, pushing the tree over and leaving one of the large roots unsevered. The severed roots can be removed gradually. The extra space may benefit the remaining trees and at least the extra light will help in the establishment of a heavier ground cover. When the final clearing is undertaken the trees will have to be removed fairly completely, root and all. It is unnecessary to finecomb the ground for rootlets unless *Fomes* is known to be present but at least all large roots must be taken up. The cost of this work will vary with circumstances but it is thought that an average of Re. 1-50 a tree should be about the maximum spent.

It has been said that to do the job thoroughly would cost about Rs. 4-50 a tree, but is it likely that the extra Rs. 3-00 spent as a safeguard against the possibility of root disease in the future will be economic ? This amounts to Rs. 300-00 per acre and *Fomes* or other outbreak will have to assume unheard-of proportions to necessitate the spending of this amount per acre on eradication during the ensuing decade.

Regarding the method of removal there are no doubt many present who are better informed than I am but it is probable that elephants or monkey grubbers will prove economic. The final removal of roots will in either case have to be done by coolies.

DISPOSAL OF TIMBER

It may be possible in certain circumstances to sell a proportion of the timber as firewood and, in fact, the possibility in specially favoured cases of selling the trees to a firewood contractor before they are felled should not be overlooked.

It has been suggested that the timber could be converted into charcoal and stored in that form as fuel for suction gas engines.

Apart from the above there is little to suggest but burning. When recourse is had to burning, however, it should be localised so as not to deplete the soil still further of organic matter. Burning over previously cut trenches or holes is recommended.

The possibility of converting wood into synthetic farmyard manure has been suggested but as no information is available as to the feasibility of this method of disposal no suggestions can be made. Furthermore the cost is likely to be high.

RENOVATION OF OLD SOILS

The question has many times been asked whether these old washed-out soils can support a further crop. In their present state I do not think so, at least satisfactorily, but there is no reason why, with care, they should not be brought back to a satisfactory condition of fertility. It is common knowledge that our Ceylon soils and probably all tropical plantation soils lack nitrogen and, even more so, organic matter. In the past many estates, as well as neglecting selection of the material to be planted, made no effort to employ careful planting methods. Stumps were put in with alavangoes and no precautions were taken to retain the original fertility of the soil. The resulting trees are smaller than they might have been and yields are lower in consequence.

Nitrogen, phosphates and potash, the active constituents of manure mixtures, can be supplied to the soil fairly cheaply nowadays but it is expensive to purchase all the organic matter

required from the manure merchant. When the old rubber is removed every possible source of potential humus must be exploited. Trees felled just after they have put on their new head of foliage will supply two lots of leaf, one on the ground and the other which can be removed from the felled trees while it is still green and in a form in which it can readily be incorporated in the soil. Large quantities of plant material should not however be dug in alone unless it is known to be fairly rich in nitrogen content. A nitrogenous manure such as calcium cyanamide or mixtures containing cyanamide should be added at the same time. The soil organisms which are responsible for the breaking down of this material make use of quantities of nitrogen-containing compounds and if this amount is not added with the green matter it must be supplied by the soil. The quantity of nitrogen thus abstracted is locked up in the bodies of these organisms during their life and is not available for plant food, and this may even suggest in some cases that the addition of green matter is detrimental. Only on their death is the store released. It is however not desirable that the numbers of these beneficial bacteria should be allowed to decrease; an increase should be aimed at, since without their presence soils become poor. They are found in their greatest numbers in soils which are said to be in good tilth.

In jungle the soil, fauna, and flora are extensive and humus is plentiful. One finds earthworms and other creatures which are almost completely absent from estate soils. Humus consists very largely of broken down plant roots and other plant debris which has been carried underground by the agency of such animals as earthworms. Unfortunately a very large proportion of these beneficial organisms are destroyed when a clearing is fired and their increase should be studied later by bringing about the right conditions for their existence. Soils which are plentifully supplied with the right organisms require little cultivation, they open up the soil in a more efficient manner than the average forking Aeration is permitted and, as plant roots breathe as well as the above ground portions, growth of plants is encouraged. For their continued existence and multiplication a sufficiency of plant residues is essential and this is most economically provided by growing, pruning, and burying large masses of green manure on the land.

The terms green manure and cover crop are frequently considered synonymous. I prefer to apply cover crops to the creeping plants whose main function is to keep the soil in position, although in most cases they also have considerable green manurial value. These will be dealt with in the next section. By green manures are meant the tall growing plants which by their nature can stand several prunings per year and survive to

produce a large bulk of material for burying. Among these are the Tephrosias, Crotalarias, some Desmodiums, Sesbanias, Indigoferas, etc., and it is to my mind desirable on replanted land to have the areas between contours full of these so that they resemble miniature forests. Only in this way will it be possible to obtain the necessary weight of organic matter to bring back the soil to a reasonable fertility.

While it is desirable to have the top foot of soil all over the plantation in a good state of tilth with sufficient humus I would advise, in the case of replanting, the localisation of burying of such material. The rubber is the main crop and burying in pits near the young plants is preferable to distributing the available material all over where most of it will be out of reach of the limited root system. When the trees get older burying will take place further away and gradually all the intervening ground may be brought to a satisfactory state.

There is one way apart from soil considerations in which this burying of green material may benefit crops. As is well known the factors which govern the growth of plants are as follows: sufficient light, sufficient heat, sufficient moisture, and a soil sufficiently rich in nitrogen, phosphates, etc. Another factor is of great importance and that is the amount of carbon dioxide in the air. All the carbon contained in the plants has been taken from the air by the leaves in the form of this gas. It is elaborated by the leaves to form starch, sugars, etc., which in turn are the raw materials with which the plant builds up new tissue, renews bark, replaces latex withdrawn, etc. Rubber itself contains little nitrogen, phosphates or potash; these manurial constituents act largely as tonics to the tree facilitating the building up of carbon containing compounds. Among the factors mentioned above, light, heat and moisture are usually present in excess in the tropics and the nutrient salts of the soil of well-kept estates are sufficient. The limit to further growth is in all probability drawn by the amount of carbon dioxide in the air. Recent experiments in England have shown that an increase in carbon dioxide in the air results in increased growth in the plants studied. There seems little reason why a different result should be experienced with rubber. The decay of organic material in the soil is productive of much carbon dioxide. Actually in the soil this gas may have an effect similar to yeast in breadmaking, puffing it out to a certain extent and making it friable. Much of it however escapes to the air and is available for further use. The more material buried therefore the more gas liberated and the reason for the luxuriant growth in jungles could probably be found in the same factor.

The burying of green manures has been dealt with at some length as I am firmly convinced that only by extensive use of this method will many of our older estates be able to grow another crop. A cover of vigna is not sufficient; material in large quantities will have to be buried.

RE-OPENING OF THE LAND: PREVENTION OF EROSION, ETC.

An opportunity such as this should be taken to do away with the old fields of varying size. The whole area should be divided up into uniformly sized blocks of as far as possible uniform shape. This is for convenience in future running. Manuring programmes, cultivation, etc., can be much more easily arranged and the land is divided up into blocks which would lend themselves to experiment should the occasion arise.

On re-opening old land it will obviously be of little use to take a lot of trouble over re-making the soil unless suitable measures are adopted to prevent further loss. Much has been written on the prevention of erosion and I propose to refer only briefly to the various methods. There are two factors which probably contribute more than anything else to soil deterioration, wind and water, the latter usually being considered the more important. The old square or rectangular system of planting with drains sloping at 1 in 40 did nothing to keep the soil in its place. Stone terraces held back the larger particles of sand and gravel but let through much of the finer particles and all the soluble part of the soil. The drains permitted of scouring and conducted a very large proportion of the water off the land. In the light of present knowledge the system has nothing to recommend it. Conservation of water in the soil is an important matter and for this reason as well as from an anti-erosion point of view surface run-off must be reduced or stopped completely.

There are now various well-known ways of preventing loss of soil but I look on contour planting in some form as a first essential where rubber is concerned. I favour the trench system of contour planting advocated by Mr. Denham Till. Here contour trenches 3 ft. by 3 ft. are cut at intervals of 20 to 24 ft. Lining is similar to any other form of contouring and it is preferable to mark off the agreed intervals between the successive contours down the hill at its steepest part. Adjacent contours will then always diverge, never converge. It is considered easier to insert short lengths where the divergence is too great than to break and start at a lower level when they come too close, one is also assured of a number of continuous contours.

During the cutting all the better soil, top soil with cover crops, is thrown uphill. This is used later for refilling purposes. The subsoil excavated is thrown out on the lower side of the trench to form a bund. Plants put in at 12 ft. intervals along such contours will give a stand of 120 to 150 trees per acre. In filling, portions of the trench only need be filled at the outset. Six ft. of trench should be filled for each plant, that is 3 ft. on either side of it. To prevent the refilled portion being washed down gradually into the intervening spaces the soil will have to be sloped so that actually a length of 8 or 9 feet will be filled at the bottom of the trench and gradually tailed off to 6 ft. at the top.

The unfilled portions afford excellent pits for the cheap burying of green manures and act as effective water traps. The green matter buried is exactly in the right place for use by the plant and so is the store of moisture.

The above system has all the erosion-preventing properties of the perhaps better known contour platform system and besides there is no check to growth caused by the roots filling the prepared hole and so becoming "pot bound."

Contour platform planting is probably next best. It is efficient as a prevention of erosion and it is less costly, at least in the first year. It does not however do away with the necessity of digging holes for the plants or pits for burying purposes.

It is thought that one or other of these methods is essential if success in replanting is to be obtained. The former method has to my mind many points to recommend it. The initial higher cost is balanced later by the extra cutting required in the other; the opening work except for burying of manure loppings is completed in one year.

In the event of lack of funds preventing the employment of either method much may be done to prevent soil movement by alteration and extension of the old drainage system. Drains sloping at 1 in 40 or so are best neglected but others with a more gentle slope may be re-cut and supplied with blocks, spills and water traps as has been described in a paper presented at a previous conference. Even here planting should be done on the contour. Generous holes will be required.

In all cases a thick growth of cover crops is essential but probably most essential where no terracing is done.

The wind factor in soil deterioration or this combined with sun must be counteracted. Winds, besides retarding growth of young plants, dry out the surface layer of soil and reduce bacterial activity. Great heat acts in the same way only probably in a more pronounced manner. Both can be controlled by shade, and ground covers of Gliricidias, Albizzias or some such small tree as *Leucaena glauca* will be essential in replanting schemes. Special wind belts may be necessary in certain cases and it may pay to leave temporarily belts of the old rubber augmented by Gliricidias in rows at intervals across the field. Regarding ground covers there is a big selection but where Vigna (*Dolichos hosei*) is already growing this will probably prove best and most easily established. Others are Calopogonium, Pueraria, and Cowpea which do not stand heavy shading and which must be regarded as temporary covers and *Centrosema pubescens* or *Indigofera endecaphylla* which if established in a clearing may persist reasonably well under older rubber.

PLANTING MATERIAL

All plants should be budded and only proved material should be used. A selection of clones may be made from the following, which are probably the most fully tested clones at present available: Tjirandji 1, 8, 16; AVROS. 49, 50, 71, 80, 152, 256; Bodjong Datar 2, 5, 10; Prang Besar 23, 25; SR 9; Cultuurtuin 88; Djasingha 1.

A budwood nursery containing the selected clones will have to be laid down at least 18 months before the first supply of budwood is required, and in such a nursery six budded stumps will be required for each acre to be budded. Establishment of budwood nurseries is discussed in a booklet entitled "The Budding of Rubber" issued by the Rubber Research Scheme. Arrangements will also have to be made about 2 years ahead for seedlings for budding purposes. 300 seedlings should be allowed for each acre to be dealt with to allow of selection of the most vigorous.

LAYOUT OF THE LAND

About two years ago the advice given on planting material was to plant a mixture of budded plants and selected seedlings. More recently estates have been advised to plant budded plants only but to mix the clones. This shows increase in faith in budding but I prefer to go on further and recommend, when proved material only is being used, that different clones be kept strictly separate. It is quite possible and indeed probable that to get the best out of certain clones special mild, or it may be heavy, tapping systems will have to be employed. Where clones

are separate each can be treated on its merits; any admixture renders this impossible. The mixing of clones has been recommended with a view to future thinning out of the poorer trees, but thinning out in the case of budded rubber consists of the complete removal of poor clones. Is it not preferable, if such action is necessary, to have a piece of ground which can be replanted rather than an area which will suffer permanently from a deficient stand of trees per acre ? By the time it has been discovered that a certain clone does not come up to expectation it will be impossible to replace it with better material in a mixed stand. Further if really proved material only is used little if any thinning out will be necessary.

A plan of layout is suggested below which allows of clones being kept separate. If the land is divided up into 10 (or 20) acre fields a certain number of these can be allotted to each clone. In the diagram the fields are shown square but in actual practice the boundary fields will usually be irregular in outline. In such a scheme there would eventually be 10 fields or blocks of each clone all adjacent.

Budding is best done in the nursery where supervision is easy and therefore it will be most convenient to have the budwood nursery and seedling nursery in close proximity to each other.

The planting out of budded plants and the subsequent attention necessary are described in the previously mentioned booklet on "Budding."

AREAS PLANTED UP WITH UNSELECTED MATERIAL DURING 1925 AND 1926

I have been frequently asked whether young rubber 4 or 5 years old grown from unselected seed could be budded satisfactorily or whether it should be cut out and replaced. I am definitely in favour of making an attempt to bud such plants. The number of successes will be fewer but the growth of the plants when successfully budded is so vigorous that to my mind the extra trouble is worth while. Plants budded at this age will reach tappable size one year at least before budded stumps put out at the same time.

In such areas there will no doubt be plants which prove very difficult to bud; these will either have to be left or replaced with budded stumps.

In connection with the budding of such comparatively old plants there are one or two points which might be mentioned. 'Green' budwood has proved preferable to the more mature brown wood. Also the 'snag' left when the stocks are cut back requires more attention. This will have to be carefully cut back to the union of stock and scion as soon as the young budded shoot is 4 to 5 ft. high, in order to reduce as much as possible the "elephant foot." The cuts heal over satisfactorily if protected by a waterproof coating of asphalt or tar.

CONCLUSION

Most points except actual costs have been touched on. A rough estimate, believed to be on the generous side has been drawn up and I propose to read this out item by item. Any information, which anyone present can give, will be welcomed as exact figures are not yet available. Discussion is invited and any questions raised will be answered as far as possible.

TAPPING ARRANGEMENTS DURING HEAVY TAPPING

It is assumed that an area is being replanted on a ten-year basis, one-tenth of the area being cleared each year. The unit of yield represents the yield which would be obtained from that area under normal tapping conditions.

Plots	1	2	3	4	5	6	7	8	9	10
1930	x	n	n	n	n	n	n	n	n	n
1931	x	x	n	n	n	n	n	n	n	n
1932	x	x	x	n	n	n	n	n	n	n
1933	≐	x	x	x	n	n	n	n	n	n
1934	0	≐	x	x	x	n	n	n	n	n
1935		0	≐	x	x	x	n	n	n	n
1936			0	≐	x	x	x	n	n	n
1937				0	≐	x	x	x	n	n
1938					0	≐	x	x	x	n
1939						0	≐	x	x	x
1940							0	≐	x	x
1941								0	≐	x
1942									0	≐
1943										0

n = tapped normally.
x = tapped both sides to normal depth.
≐ = final tapping.
0 = trees cut out.

EXPECTATION OF CROP UNDER HEAVY TAPPING SUGGESTED

(Previous Yield taken as 300 lb. per acre)

Plot	...	A	B	C	D	E	F	G	H	I	J	Total	
1930	...	450	300	300	300	300	300	300	300	300	300	3150	
1931	...	450	450	300	300	300	300	300	300	300	300	3300	
1932	...	450	450	450	300	300	300	300	300	300	300	3450	
1933	...	750	450	450	450	300	300	300	300	300	300	3900	
1934	...		750	450	450	450	300	300	300	300	300	3600	
1935	...			750	450	450	450	300	300	300	300	3300	
1936	...				750	450	450	450	300	300	300	3000	
1937	...					750	450	450	450	300	300	2700	
1938	...						750	450	450	450	300	2400	
1939	...							750	450	450	450	2100	
1940	...								750	450	450	1650	
1941	...	700								750	450	1900	
1942	...	850	700								750	2300	
1943	...	1000	850	700								2550	39300
1944	...	1000	1000	850	700							3550	
1945	...	1000	1000	1000	850	700						4550	
1946	...	1000	1000	1000	1000	850	700					5550	
1947	...	1000	1000	1000	1000	1000	850	700				6550	
1948	...	1000	1000	1000	1000	1000	1000	850	700			7550	
1949	...	1000	1000	1000	1000	1000	1000	1000	850	700		8550	
1950	...	1000	1000	1000	1000	1000	1000	1000	1000	850	700	9550	
1951	...	1000	1000	1000	1000	1000	1000	1000	1000	1000	850	9850	
1952	...	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	10000	105000*

* Yield for the same period without replanting 69,000 lb.

COSTS

Complete removal of trees (including loppings of leafy twigs and stacking any firewood to be burnt (generous)	Rs. 150·00
Trench cutting, 30 chains @ Rs. 5/- (generous)	,, 150·00
Filling and making of Adco	,, 40·00
Cover crops, seed and planting	,, 15·00
Planting	,, 5·00
Weeding @ Rs. 12/- for 3 years	,, 36·00
,, @ ,, 4/- ,, ,, ,, ...	,, 12·00
Lopping green manures first year. ...	,, 4·00
,, ,, ,, subsequent years @ 5/-	,, 25·00
Budding @ -/05 per plant (excluding cost of budwood)	,, 6·25
Nurseries	,, 20·00
Seed @ -/01 each	,, 3·00
Baskets (?)	,, 2·00
Roads remaking	,, 10·00
Manuring 1st year	,, 6·00
,, 2nd ,, ...	,, 10·50
,, 3rd ,, ...	,, 19·50
,, 4th ,, ...	,, 19·50
,, 5th ,, ...	,, 30·00
,, 6th ,, ...	,, 38·00
	Rs. 601·75

A stump-removing wrench should be obtained and the cost distributed among the acres. This is included in the above.

It is presumed that unless the whole of an estate is being replanted there will be no general charges set down against the area in question.

PROBABLE DISTRIBUTION OF COSTS

Block		1	2	3	4	5	6	7	8	9	10	Total
Year.												
1931 1st	...	423·25	—	—	—	—	—	—	—	—	—	423·25
1932 2nd	...	27·50	423·25	—	—	—	—	—	—	—	—	450·75
1933 3rd	...	36·50	27·50	432·25	—	—	—	—	—	—	—	487·25
1934 4th	...	28·50	36·50	27·50	423·25	—	—	—	—	—	—	515·75
1935 5th	...	39·00	28·50	36·50	27·50	423·25	—	—	—	—	—	554·75
1936 6th	...	47·00	39·00	28·50	36·50	27·50	423·25	—	—	—	—	601·75
1937 7th	...	—	47·00	39·00	28·50	36·50	27·50	423·25	—	—	—	601·75
1938 8th	...	—	—	47·00	39·00	28·50	36·50	27·50	423·25	—	—	601·75
1939 9th	...	—	—		47·00	39·00	28·50	36·50	27·50	423·25	—	601·75
1940 10th	...	—	—	—	—	47·00	39·00	28·50	36·50	27·50	423·25	601·75
1941 11th	...	—	—	—	—	—	47·00	39·00	28·50	36·50	27·50	178·50
1942 12th	...	—	—	—	—	—	—	47·00	39·00	28·50	36·50	151·00
1943 13th	...	—	—	—	—	—	—	—	47·00	39·00	28·50	114·50
1944 14th	...	—	—	—	—	—	—	—	—	47·00	39·00	86·00
1945 15th	...	—	—	—	—	—	—	—	—	—	47·00	47·00
											Rs.	6,017·50

This means that assuming that each year's clearing extended to only one acre the total cost of bringing the whole 10 acres into bearing would be Rs. 6,017-50 distributed as above. As mentioned already this estimate is on the generous side.

TIME-TABLE

The one-acre blocks are labelled ABC . . . . J

Year ...	Tapping both sides	Final Tapping	Cut out	Bud-wood nursery	Plant supply nursery	Budding	Plant out
1930 ...	A			Plant			
1931 ...	AB			Bud	For A		
1932 ...	ABC			Bud	,, B		
1933 ...	BCD	A			,, C	For A	
1934 ...	CDE	B	A		,, D	,, B	A
1935 ...	DEF	C	B		,, E	,, C	B
1936 ...	EFG	D	C		,, F	,, D	C
1937 ...	FGH	E	D		,, G	,, E	D
1938 ...	GHI	F	E		,, H	,, F	E
1939 ...	HIJ	G	F		,, I	,, G	F
1940 ...	IJ	H	G		,, J	,, H	G
1941 ...	J	I	H			,, I	H
1942 ...		J	I			,, J	I
1943 ...			J				J

LAYOUT OF THE LAND

Year Planted (10-year programme)

		1930	**1931**	**1932**	**1933**	**1934**	**1935**	**1936**	**1937**	**1938**	**1939**
CLONES	Tji 1	Tji 1 1930.									
	Tji 16	Tji 16 1930.									
	AV. 49	AV. 49 1930.									
	AV. 50	AV. 50 1930.									
	BD. 5	BD. 5 1930.									
	BD. 10	BD. 10 1930.									

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st OCTOBER, 1930

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1930	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	1151	251	202	760	31	158
	Foot-and-mouth disease	262	...	252	10	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Colombo Municipality	Rinderpest	..	...	...	...	...	...
	Foot-and-mouth disease	447	...	434	12	...	1
	Anthrax	28	4	...	28	...	...
	Haemorrhagic Septicaemia	6	...	...	6	...	...
	Black Quarter	2	...	...	2	...	...
	Bovine Tuberculosis	1	...	...	1	...	...
	Rabies (Dogs)	11	...	...	...	...	11
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	..	...	...	...	...
	Anthrax	652 *	52	...	652	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	650	...	648	2	...	...
	Anthrax	1	...	...	1	...	...
	Piroplasmosis	4	...	1	3	...	...
	Rabies (Dogs)	12	1	...	10	...	2
Southern	Rinderpest	295	12	66	225	4	...
	Foot-and-mouth disease	269	...	263	6	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	3	2	...	2	...	1
Northern	Rinderpest	4	...	3	1	...	...
	Foot-and-mouth disease	2975	...	2905	70	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	224	...	...	224	...	...
	Rabies (Dogs)	3	...	...	...	...	3
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	100	...	98	2	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	5833	760	290	4629	34	880
	Foot-and-mouth disease	135	...	135	...	..	...
	Anthrax	...	...	...	...	...	...
	Pleuro-Pneumonia (in Goats)	50	...	...	50	...	...
North-Central	Rinderpest	763	509	63	594	9	97
	Foot-and-mouth disease	1069	...	1045	24	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	72	...	72	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	3	1	...	...	...	3
Sabaragamuwa	Rinderpest	63	...	7	54	...	2
	Foot-and-mouth disease	1455	...	1445	10	...	...
	Anthrax	..	...	...	...	...	...
	Haemorrhagic Septicaemia	65	15	...	65	...	...
	Rabies (Dogs)	14 †	1	...	4	...	10

* 1 case in a buffalo—Rest sheep and goats. † 1 case—a calf.

G. V. S. Office,
Colombo, 10th November, 1930.

G. W. STURGESS,
Government Veterinary Surgeon.

METEOROLOGICAL REPORT

OCTOBER, 1930

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo	84·4	+0·1	73·9	−0·6	82	93	8·8	33·38	26	+20·28
Puttalam	84·6	−1·0	74·0	−0·7	83	95	7·3	13·68	25	+ 4·94
Mannar	86·0	−1·2	76·3	−0·6	79	91	8·7	16·24	16	+ 8·57
Jaffna	83·9	−0·3	75·4	−2·2	84	93	7·2	19·89	20	+10·60
Trincomalee	85·6	−1·8	74·5	+0·8	79	90	6·8	17·25	23	+ 9·01
Batticaloa	85·6	−1·0	74·4	+0·1	75	93	7·0	13·25	22	+ 6·81
Hambantota	85·3	−0·2	74·4	+0·1	80	93	6·0	2·63	18	− 2·10
Galle	82·2	−0·5	74·5	−0·8	86	93	7·0	10·11	21	− 2·90
Ratnapura	86·3	+0·7	72·4	−0·7	82	95	7·5	28·05	26	+ 9·45
A'pura	86·8	−1·8	73·7	+0·1	78	93	8·7	15·46	22	+ 5·95
Kurunegala	85·7	−1·3	72·7	−0·1	78	95	8·3	30·89	26	+15·46
Kandy	82·7	+0·3	68·6	+0·2	78	95	7·7	17·71	26	+ 6·20
Badulla	81·1	−1·5	66·0	+1·2	80	97	6·8	16·92	25	+ 7·37
Diyatalawa	75·5	+0·3	60·6	+0·4	80	91	7·6	15·87	27	+ 6·00
Hakgala	68·5	−1·5	56·5	+1·3	86	88	6·3	27·16	28	+15·23
N'Eliya	67·0	+0·3	52·5	+1·5	86	97	8·5	18·64	27	+ 7·78

The rainfall of October was above average at almost every station in the Island, the excess being most marked in the Ambegamuwa, Watawala, and Matale districts, and along the west coast from Colombo to Chilaw. Besides the above areas, totals for the month that were more than 15 inches above their average were common throughout the Kelani Valley and in the Northern Province.

The excess was quite definite throughout, but was least marked in the E.P. and S.P., where one or two stations (though not the majority) were below average.

During the first few days of the month there was heavy rain near the coast, and figures included over 10 inches at the Colombo stations on the 3rd, on which day falls of over 5 inches were recorded at Chilaw, Maggona, Angoda and intermediate places. From the 5th to the 21st (and particularly on the 14th) rain occurred in the form of irregularly distributed thunderstorms, but on the morning of the 21st a depression was located with its centre north-east of the Island. The depression moved westward and crossed the Indian coast near Negapatam on the 24th. It caused heavy rain in Ceylon with consequent flooding, and though its worst efforts were on the 21st to 23rd, it continued to give considerable rain up to the 29th, after which the last two days of the month were practically clear. More than fifty stations recorded falls of at least 5 inches in a day during the passage of this depression, the highest figures being 10·3 at Oonoogaloya, 10·2 at Point Pedro, and 10·1 at Chavakachcheri.

One indirect result of the depression was that the accompanying squalls on the west coast were from the west or south-west.

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